$$a = \frac{54\times1200 \pm \sqrt{(\ldots)\ldots\times18\times72}}{2\times(44\pi)^2}$$

$$a = \frac{64800 \pm \sqrt{4220000000 + 1296\times19\times1500}}{2\times 197800}$$

$$= \frac{64800 \pm \sqrt{422\times10^7 + 5184\times19\times500}}{395600}$$

$$= \frac{64800 \pm \sqrt{422\times10^7 + 1015000000}}{39600}$$

$$= \frac{64800 \pm \sqrt{42.2\times10^8 + 10.15\times10^8}}{39600}$$

$$= \frac{64800 \pm 10^4\sqrt{52.45}}{39600}$$

$$= \frac{64800 \pm 10^4\times7.25}{39600}$$

$$= \frac{64800 \pm 72500}{39600}$$

$$a = \frac{64800+72500}{39600}$$

$$= \frac{132900}{39600} = 3.35\ in^2$$

(2)

$$f = \frac{\text{Stress}}{\text{Strain}} = \frac{2\theta}{3}$$

$$\frac{2\theta}{3} = \frac{2\times 1/2}{a}$$

$$480a - 36 = \sqrt{18\times72 + 54\times1200a}$$

$$480a - 36 = \sqrt{1296 + 64800a}$$

$$(480a)^2 - 2\times480\times36a + (36)^2 = 1296 + 64800a$$

$$230400a^2 - 34560a + \cancel{1296} = \cancel{1296} + 64800a$$

$$230400a^2 - 64800a - 34560 = 0$$

$$a = \frac{-(-648000 \pm \sqrt{(64800)^2 - 4\times230400\times-34560}}{2\times230400}$$

$$a = \frac{648000 \pm \sqrt{4220000000 + 921600\times34560}}{460800}$$

$$= \frac{648000 \pm \sqrt{4220000000 + 31860000000}}{460800}$$

$$= \frac{648000 \pm \sqrt{4.22\times10^{10} + 3.186\times10^{10}}}{460800}$$

$$= \frac{648000 \pm 10^5\times\sqrt{32.282}}{460800}$$

$$= \frac{648000 \pm 10^5\times5.67}{460800}$$

$$= \frac{64800+567000}{460800} = \frac{631800}{460800} = 1.4\ in^2$$

(2)

$$14\times? \quad f = \frac{W}{a} + \sqrt{\frac{W^2l^2 + 2WEalh}{al}}$$

$$f=1$$

$$14\times2240 = \frac{560}{\frac{\pi}{4}\times\frac{1}{4}} + \frac{\sqrt{(560)^2\times(120)^2 + 2\times560\times30\times10^6\times\frac{\pi}{16}\times120h}}{\frac{\pi}{16}\times120}$$

$$31360 = \frac{560}{.1965} + \frac{\sqrt{4.502\times10^{10} + 7920\times10^7h}}{23.55}$$

$$31360 = 2846 + 10^5\times\sqrt{4.502 + 79.2h\ldots}$$

$$f = \frac{w}{a} + \frac{\sqrt{w^2 l^2 + \dots}}{al}$$

$$14 \times 2240 = \frac{560}{\frac{\pi}{16}} + \frac{\sqrt{(560)^2(120)^2 + 2 \times 560 \times 30 \times 10^6 \times \frac{\pi}{16} \times 120h}}{\frac{\pi}{16} \times 120}$$

$$31360 = \frac{560}{.1965} + \frac{\sqrt{313600 \times 14400 + 2 \times 3 \times 12 \times \pi \times 10^9 h}}{23.55}$$

$$31360 = 2850 + \frac{\sqrt{4516000000 + 792 \times 10^9}}{23.55}$$

$$28510 = \frac{\sqrt{.452 \times 10^{10} + 79.2 \times 10^{10} h}}{23.55}$$

$$28510 \times 23.55 = 10^5 \times \sqrt{79.2h + .452}$$

$$(671400)^2 = 10^{10} \times \{79.2h + .452\}$$

$$(6.72)^2 \times \cancel{10^{10}} = \cancel{10^{10}} \{79.2h + .452$$

$$45.2 = .452 + 79.2h$$

$$h = .565$$

$$f = \frac{w}{a} + \frac{\sqrt{w^2 l^2 + 2wEalh}}{al}$$

$$\frac{20}{3} = \frac{1}{2a} + \frac{\sqrt{\frac{1}{4} \times 72 \times 72 + 2 \times \frac{1}{2} \times 12000 \times a \times 72 \times \frac{3}{4}}}{72a}$$

$$480a = 36 + \sqrt{1296 + 648000a}$$

$$230400a^2 - 72 \times 480a + \cancel{1296} = \cancel{1296} + 648000$$

$$a = 2.9 \text{ in}^2$$

သတ္တုများ၏ ဂုဏ်သတ္တိများ

mechanical properties of materials

Elastic Limit (ဂုဏ်ပြန်စည်း)

ဂုဏ်ပြန်စည်းဆိုသည်မှာ ဝန်ဖြုတ်လိုက်၍ အလျားပယောဂကြီး အနည်းဆုံး ဝန်ကို ဆိုလိုသည်။ ဝန်သည် ဂုဏ်ပြန်စည်းကျော်၍ မှသာ ဝန်ဖြုတ်လိုက် အလျားပယောဂ ကျန်ပေမည်။

Permanent set

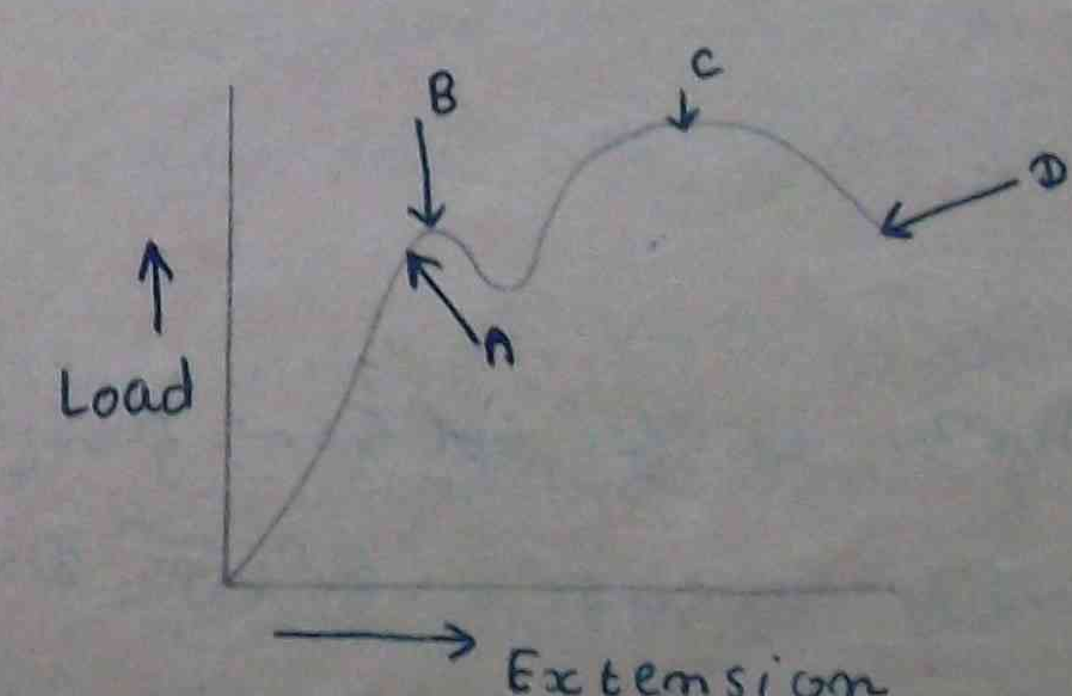
ဝန်ကိုအကြာကြီး တင်ထား၍ ဖြုတ်လိုက် မူလအလျားအနည်းငယ် ပယောဂကြီး ရှည်နေ ပြန်မဖြစ်တော့ permanent set ကျန်ရစ်ပါ။

Elasticity Engineer များသုံးသော သတ္တု၊ သစ်၊ ကွန်ကရစ် စသည့် ပစ္စည်းများတွင် ဂုဏ်ပြန်သတ္တိ (Elasticity) ရှိပါ ဝန်ထမ်းဝန်ကို ဖြုတ်လိုက်သောအခါ အလျားပယောဂ ကျယ်ပါက မူလပုံသဏ္ဌာန် ပြန်ဖြစ်ပါ။ ဝန်ထမ်းသည့်ပစ္စည်း ပြန်သော ပစ္စည်း Elasticity ဖြစ်ပေါ် (ဤသော ဝန်သည် ဂုဏ်ပြန်စည်း Elasticity limit ကျော်၍ မှသာ ဝန်ဖြုတ်လိုက်လျှင် အလျားပယောဂ ကျယ်ပါ ဝန်ကိုအကြာ မတင်ထားပါ မှ ဖြုတ်လိုက်လျှင် အလျားအနည်းငယ် သာ ပယောဂကြီး မူလပုံမဖြစ်တော့ permanent set ကျန်ရစ်ပါ။) plasticity.

ပုံ ၇၀(၁)

Load - Extension curve

ETCC { behaviour of mild on testing machine called Extensiometer }



ပေးထားသောပုံတွင် mild steel bar တချောင်းကို အားဆွဲ၍သော အခါ ၎င်း bar ၏ အလျားသည် အဆိုပါ ဖြစ်ပေါ်နေသည့် အခြေအနေကို ဖော်ပြသောပုံဖြစ်သည်။ ပုံတွင် ၎င်းသံချောင်း၏ အရေးကြီးသော အခြေအနေရပ်များကို A, B, C, D နေရာတို့ဖြင့် ဖော်ပြထားသည်။ ၎င်းတို့မှ A, (Elastic limit) ဂုဏ်ပြန်စည်း၊ B (Yield point), C (maximum load), D (Breaking Point)

Elastic limit - [illegible]

[illegible]

① $f = \frac{w}{a} + \sqrt{\frac{w^2l^2+2wEalh}{al}}$

$$\frac{1}{1800} = \frac{1}{2a} + \sqrt{\frac{(\frac{1}{2})^2\times(72)^2+2\times\frac{1}{2}\times 12000\times a\times 72\times\frac{3}{4}}{a\times 72}}$$

$$\frac{1}{1800}-\frac{1}{2a} = \sqrt{\frac{18\times72+648000a}{72a}}$$

$$\left(\frac{1}{1800}\right)^2 - 2\times\frac{1}{1800}\times\frac{1}{2a}+\frac{1}{4a^2} = \frac{18\times72+648000a}{72\times72a^2}$$

$$\frac{\cancel{a^2} + 900\times900 - 900\times2a\times2}{4\times1800\times1800a^2} = \frac{18\times72+648000a}{72\times72a^2}$$

$$a = 1.09\ in^2$$

② $f = \frac{w}{a} + \sqrt{\frac{w^2l^2+2wEalh}{al}}$

$$14 = \frac{\frac{1}{4}}{\frac{\pi}{4}\times\frac{1}{4}} + \sqrt{\frac{(\frac{1}{4})^2\times(120)^2+2\times\frac{1}{4}\times30\times10^6\times\frac{\pi}{16}\times h}{\frac{\pi}{4}\times\frac{1}{4}\times120}}$$

$\therefore h = 3.49''$

[illegible] stress [illegible] area [illegible] limit of proportionality [illegible]

(Yield point)

[illegible] permanent set [illegible] Yield point [illegible] stress [illegible] area [illegible]

$$\text{Yield stress} = \frac{\text{Load at Yield Pt}}{\text{original area}}$$

Maximum load

[illegible] extension [illegible]

Breaking point

[illegible] area [illegible] stress [illegible]

([illegible] ultimate stress [illegible] area [illegible])

$$\boxed{\text{ultimate strength} = \frac{\text{max: load}}{\text{original sectional area}}}$$

[illegible] (Factor of safety) [illegible] (working stress) [illegible]

$$\boxed{\text{working Stress} = \frac{[illegible]}{\text{Factor of Safety}}}$$

→ Top group (1)

Ductility [illegible]

[illegible] Ductile [illegible]

Stiffness

[illegible] Stiffness [illegible] spring [illegible] Stiffness [illegible] Stiffness [illegible] Stiffness [illegible]

Toughness

[illegible] Toughness [illegible] Toughness [illegible] (1) [illegible] (2) [illegible] (3) degree [illegible]

[illegible]
Compound Bar

[illegible] modulus of Elasticity [illegible] E [illegible]

[illegible] A_1 = [illegible]

A_2 = [illegible]

W = [illegible]

W_1 = [illegible]

W_2 = [illegible]

E_1 = [illegible] modulus of Elasticity

E_2 = [illegible] modulus of Elasticity

L = [illegible]

l = [illegible]

[illegible] –

$$\frac{l}{L} = [illegible] = \frac{[illegible]}{\text{modulus of Elasticity}}$$

$$\frac{f_1}{E_1} = \frac{f_2}{E_2}$$

$$\frac{\frac{W_1}{A_1}}{E_1} = \frac{\frac{W_2}{A_2}}{E_2}$$

$$\frac{W_1}{A_1 E_1} = \frac{W_2}{A_2 E_2}$$

$W_1 = A_1 f_1$
$W_2 = A_2 f_2$

$$\boxed{W_1 = W_2 \frac{A_1 E_1}{A_2 E_2}}$$

$W = W_1 + W_2 = A_1 f_1 + A_2 f_2$

$$W = W_1 + W_2 = W_2\left(\frac{A_1 E_1}{A_2 E_2} + 1\right)$$

$$W_2 = \frac{W}{\frac{A_1 E_1}{A_2 E_2} + 1} = \frac{W A_2 E_2}{A_1 E_1 + A_2 E_2}$$

$$\boxed{W_2 = \frac{W A_2 E_2}{A_1 E_1 + A_2 E_2}}$$

[illegible] 1½" [illegible] 2½" [illegible] 10 tons [illegible] 12" [illegible] (က) [illegible]

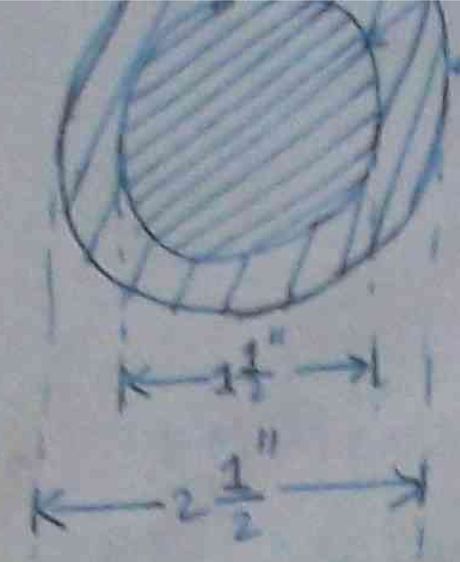
E_{st} = 13000 ton/□"

E_{cu} = 7000 ton/□" [illegible]

$f_c = 2 \times 10^6$

$f_{st} = 30 \times 10^6$ $f_i = 30 \times 10^6$

$f_{cu} = 12 \times 10^6$



cross sectional area of copper Bar $= \frac{22}{4\times7} \times \left(\frac{3}{2}\right)^2$

cross sectional area of steel Bar $= \frac{22}{7\times4} \times \left\{\left(2\tfrac{1}{2}\right)^2 - \left(1\tfrac{1}{2}\right)^2\right\}$

cross sectional of copper Bar $= .7854 \times \frac{9}{4}$

$= 1.76$ sq in

cross sectional area of steel Bar $= .7854 \left\{\frac{25}{4} - \frac{9}{4}\right\}$

$= .7854 \ \frac{25-9}{4}$

$= .7854 \times 4$

$= 3.1416$ sq in

[illegible] w ton [illegible]

[illegible] $(10-w)$ tons [illegible]

[illegible]

$$\frac{\frac{w}{1.76}}{7000} = \frac{\frac{10-w}{3.14}}{13000}$$

$3.14w \times 13000 = (10-w) \times 7000 \times 1.76$

$40800w = 123200 - 12320w$

$(40800 + 12320)w = 123200$

$53120\ w = 123200$

$w = \frac{12320}{5312} = 2.32$ tons

(2.32)

$\therefore (10-w) = 7.68$ tons

[illegible] $= \frac{\text{ဝန်}}{\text{area}} = \frac{2.32}{1.76} = 1.319$ ton/in^2

(1.32)

[illegible] $= \frac{\text{ဝန်}}{\text{area}} = \frac{7.68}{3.14} = 2.445$ ton/$\square$"

(1.32, 2.44)

Ans (2.44)

E: $7000 = \frac{\text{[illegible]}}{\frac{\text{[illegible]}}{\text{[illegible]}}} = \frac{1.32}{\frac{\text{[illegible]}}{12''}}$

$\therefore$ [illegible] $= \frac{12\times1.32}{7000} = \frac{15.84}{7000} = 2.26 \times 10^{-3}$

[illegible] $= .00226''$

(Ans

Prob [illegible] 1" [illegible] 0.1" [illegible]

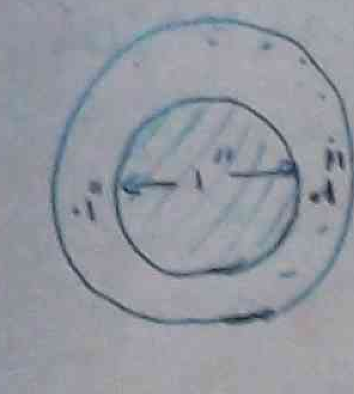
[illegible] 1" [illegible]

[illegible] 2 tons [illegible] modulus

of Elasticity [illegible] modulus of Elasticity [illegible] $\frac{16}{30}$ [illegible]

[illegible]

$E_{cu} = \frac{16}{30} E_s$



[illegible] f_s lb/$\square$" [illegible]

[illegible] f_{cu} lb/$\square$" [illegible]

[illegible] E [illegible] E_s [illegible] E_{cu} [illegible]

[illegible] cross sectional area $= \frac{\pi}{4} \times 1^2 = .7854$ in^2

[illegible] cross sectional area $= \frac{\pi}{4}(1.2^2 - 1^2)$

" $= \frac{\pi}{4} \times (1.44 - 1)$

" $= .7854 \times .44 = .3457$ in^2

[illegible] $= w$ tons

$\therefore$ [illegible] $= 2-w$ tons

[illegible] $\frac{\frac{w}{.7854}}{E_s} = \frac{\frac{2-w}{.3457}}{E_{cu}}$

$$\frac{\frac{w}{.7854}}{E_s} = \frac{\frac{2-w}{.3457}}{\frac{16}{30}E_s}$$

$$\frac{w}{.7854} \times \frac{16}{30} = \frac{2-w}{.3457}$$

$$\frac{8w}{11.78} = \frac{2-w}{.3457}$$

$8 \times .3457w = 2 \times 11.78 - 11.78w$

$2.766w = 23.56 - 11.78w$

$\therefore w = \frac{23.56}{2.766 + 11.78}$

$w = \frac{23.56}{14.546}$

Steel $= 1.62$ Tons

$$f_{steel} = \frac{1.62}{.7854} = 2.062 \text{ tons/in}^2$$

$$f_{copper} = \frac{.38}{.3457} = 1.1 \text{ tons/in}^2 \quad \text{(Ans)}$$

* ✓ ETEC

① အပြင်အချင်း 1.5" အတွင်းအချင်း 1.25" ရှိသော သံမဏိပြွန်ထဲတွင် အချင်း 1" ရှိသော ကြေးနီလုံးဒုတ်တချောင်းအား ထိုင်ခုံ ထားပါ၏။ ... အလျား 2.5 tons ဖြင့် ... ကြေးနီ ... ဖိအား tom/□" ဖြင့် ရှာပါ။

သံမဏိ E သည် ကြေးနီ၏ E ၏ 1.875 ဆဖြစ်ပါ၏။

$E_{BR} = 6500 \text{ tons}/□"$ [Ans:- ကြေးနီ = 1.39 tom/□", သံ = 2.6 tom/□"]

ကြေးနီခံရသော အလေး = x tons ဖြစ်ပါ။

သံမဏိခံရသော အလေး = $2.5 - x$ tons

~~ပေး~~ $E_{st} = 1.875\,E_{cu}$

ကြေးနီ strain = သံမဏိ strain

$$\frac{Stress_{cu}}{E_{cu}} = \frac{Stress_{st}}{E_{st}}$$

$$\frac{F_{cu}}{A_{cu}E_{cu}} = \frac{F_{st}}{A_{st}E_{st}}$$

$$\frac{x}{\frac{\pi}{4}\times 1^2 \times \cancel{E_{cu}}} = \frac{2.5 - x}{\frac{\pi}{4}\times(1.5^2 - 1.25^2)\times 1.875\,\cancel{E_{cu}}}$$

$$x\,(1.5^2 - 1.25^2)\times 1.875 = 2.5 - x$$

$$x\,(2.25 - 1.5625)\times 1.875 = 2.5 - x$$

$$x \times .6875 \times 1.875 = 2.5 - x$$

$$1.29x = 2.5 - x$$

$$2.29x = 2.5$$

$$x = \frac{2.5}{2.29} = 1.092$$

$$Stress_{cu} = \frac{F}{A} = \frac{1.092}{.7854} = 1.392 \text{ ton/in}^2$$

$$F_{st} = 2.5 - 1.092 = 1.408 \text{ tons}$$

$$\therefore f_{steel} = \frac{1.408}{.7854 \times .6875} = \frac{1.408}{.54} = 2.61 \text{ tons/in}^2$$

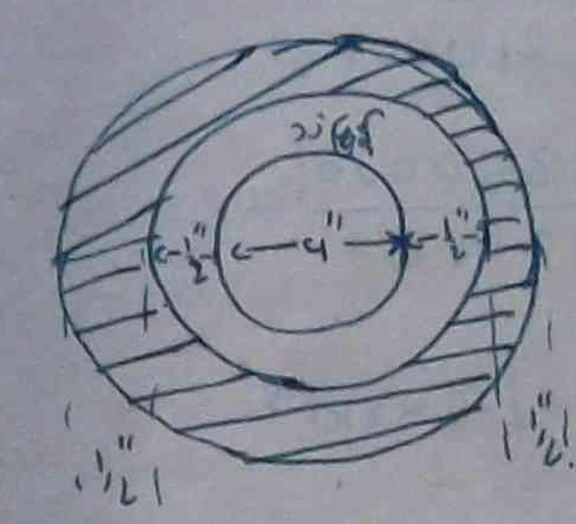
Prob ETEC

② အတွင်းအချင်း 4" ရှိ၍ အထူ 1/2" ရှိသော သံပြွန်ကို 1/2" ထူသော ကြေးနီပြွန်အတွင်း၌ ... 1/2 ton ဝန်ကို ... သံမဏိပြွန်နှင့် ကြေးနီပြွန်တို့သည် ဝန်ကို မည်မျှစီ ခံရသနည်း ရှာပါ။

ပြွန်အရှည် 3 1/2"

$E_{st} = 30\times10^6 \text{ lb}/□"$

$E_{cu} = 12\times10^6 \text{ lb}/□"$



သံပြွန်အတွက် $A = \frac{\pi}{4}d^2$

$A = \frac{\pi}{4}(5^2 - 4^2)$

$= \frac{\pi}{4}\times 9$

ကြေးနီပြွန်အတွက် $A = \frac{\pi}{4}d^2$

$A = \frac{\pi}{4}(6^2 - 5^2)$

$A = \frac{\pi}{4}\times 11$

$\therefore$ သံမဏိ strain = ကြေးနီ strain

သံမဏိ ထမ်းသောဝန် = x ton

ကြေးနီ " = $\frac{1}{2} - x$

$$\frac{Stress_{st}}{E_{st}} = \frac{Stress_{cu}}{E_{cu}}$$

$$\frac{F}{A\times E} = \frac{F}{A\,E}$$

$$\frac{x}{\frac{\pi}{4}\times 9\times 30\times10^6} = \frac{\frac{1}{2} - x}{\frac{\pi}{4}\times 11\times 12\times 10^6}$$

$$\frac{x}{270} = \frac{1 - 2x}{22\times12}$$

$$\frac{x}{270} = \frac{1 - 2x}{264}$$

$$264x = 270 - 540x$$

$$804x = 270$$

$$x = \frac{270}{804} = .336 \text{ tons} = 753 \text{ lbs}$$

ကြေးနီပြွန်ခံဝန် = $.5 - .336 = .164$ tons

$= .164 \times 2240$

$= 367$ lbs

$$\text{Strain} = \frac{\cdot 336}{\frac{\pi}{4} \times 9 \times 30 \times 10^6} = \frac{\cdot 336}{\cdot 7854 \times 9 \times 30 \times 10^6}$$

$$\frac{x}{L} = \frac{3360 \times 2240}{7854 \times 9 \times 30 \times 10^6}$$

$$x = \frac{\cancel{3360}^{1680} \times 7/\cancel{2} \times 2240}{7854 \times 27 \times 10^7}$$

$$= \frac{1680 \times 7 \times 2240}{7854 \times 27 \times 10^7} = \frac{11760 \times 2240}{212100 \times 10^7}$$

$$= \frac{11760 \times 2240}{2121 \times 10^9} = \frac{26350000}{2121 \times 10^9}$$

$$= \frac{2635}{2121} \times 10^{-5} = 1.24 \times 10^{-5}$$

$$= \cdot 0000124 \text{ in}$$

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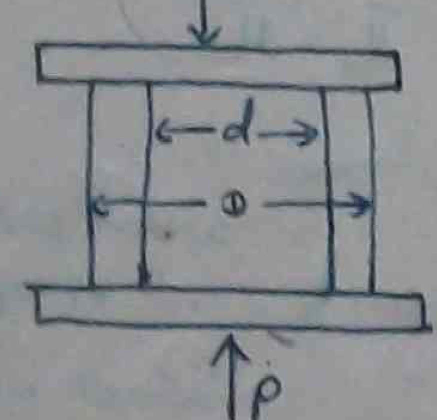
(3)



ပုံတွင်ပြထားသော သံမဏိ [illegible] ကြေးပြွန် တို့သည် plate နှစ်ခုကြား P အား [illegible] [illegible]

P = 10000 lb

D = 8"

d = 4"

$E_{St} = 30 \times 10^6$ lb/□"

$E_{Br} = 16 \times 10^6$ lb/□"

(3060 lb/□" .000102

f Br = 1635 lb/□" ·00

.0001022

---

(4) သံမဏိ [illegible]

ကြေးပြွန်

1000000 lb [illegible]

[illegible] 1000000 lb [illegible]

[illegible]

[illegible]

$E_{St} = 30 \times 10^6$

$E_{Br} = 16 \times 10^6$

$$\text{Stress} = \frac{F}{A}$$

$$= \frac{100,00,00 \times 2}{\frac{\pi}{4} \times d^2}$$

$$= \frac{\cancel{1000000} \times 2}{\frac{\pi}{\cancel{4}} \times 16} = \frac{500000}{\pi}$$

$$= 159200 \text{ lb/in}^2$$

$$\text{Strain} = \frac{\text{Stress}}{E} = \frac{159200}{30 \times 10^6} = \frac{1592}{30 \times 10000} = \cdot \frac{1592}{30}$$

$$= \cdot 053$$

ကြေးပြွန် [illegible]

$$\text{Stress} = \frac{F}{A}$$

$$= \frac{100,00,00 \times 2}{\frac{\pi}{4}(8^2 - 4^2)}$$

$$= \frac{200,00,00}{\frac{\pi}{4} \times (64 - 16)}$$

$$= \frac{200,00,00}{\frac{\pi}{\cancel{4}} \times \cancel{48}^{12}} = \frac{2000000}{377} = 5310 \text{ lb/in}^2$$

$$\text{Strain} = \frac{\text{Stress}}{E} = \frac{5310}{16 \times 10^6} = \frac{\cdot 00531}{16} =$$

$$= \cdot 0003319$$

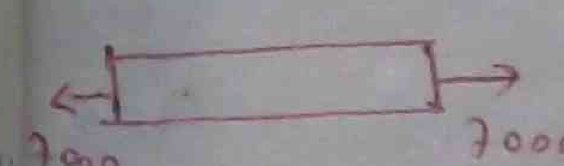
---

(3) * P [illegible]

$$F_1 \qquad F_1$$

$$\text{Strain}_{St} = \text{Strain}_{cu}$$

$$\frac{F_1}{\frac{\pi}{4} \times 16 \times 30 \times 10^6} = \frac{F_2}{\frac{\pi}{4} \times 48 \times 16 \times 10^6}$$



* [illegible] 7000 * [illegible]

$$8F_1 - 5F_2 = 0 \quad \text{——(1)}$$

$$F_1 + F_2 = 5 \times 10^5 \quad \text{——(2)}$$

$$(2) \times 5 \Rightarrow \quad 5F_1 + 5F_2 = 5 \times 10^5$$

$$8F_1 - 5F_2 = 0$$

$$13F_1 = 5 \times 10^5$$

$$F_1 = \frac{500,00,0}{13}$$

$$= 38450$$

$$F = \frac{38450}{4\pi} = \frac{38450}{12.58}$$

$$= 3066 \qquad \text{Strain} = \frac{3066}{30 \times 10^6} = \cdot 000102$$

$$F_2 = 5000000 - 30660 = 4969340 \qquad f = \frac{4969340}{377} = 2536$$

$F_2 = 100000 - 38868 = \ldots$

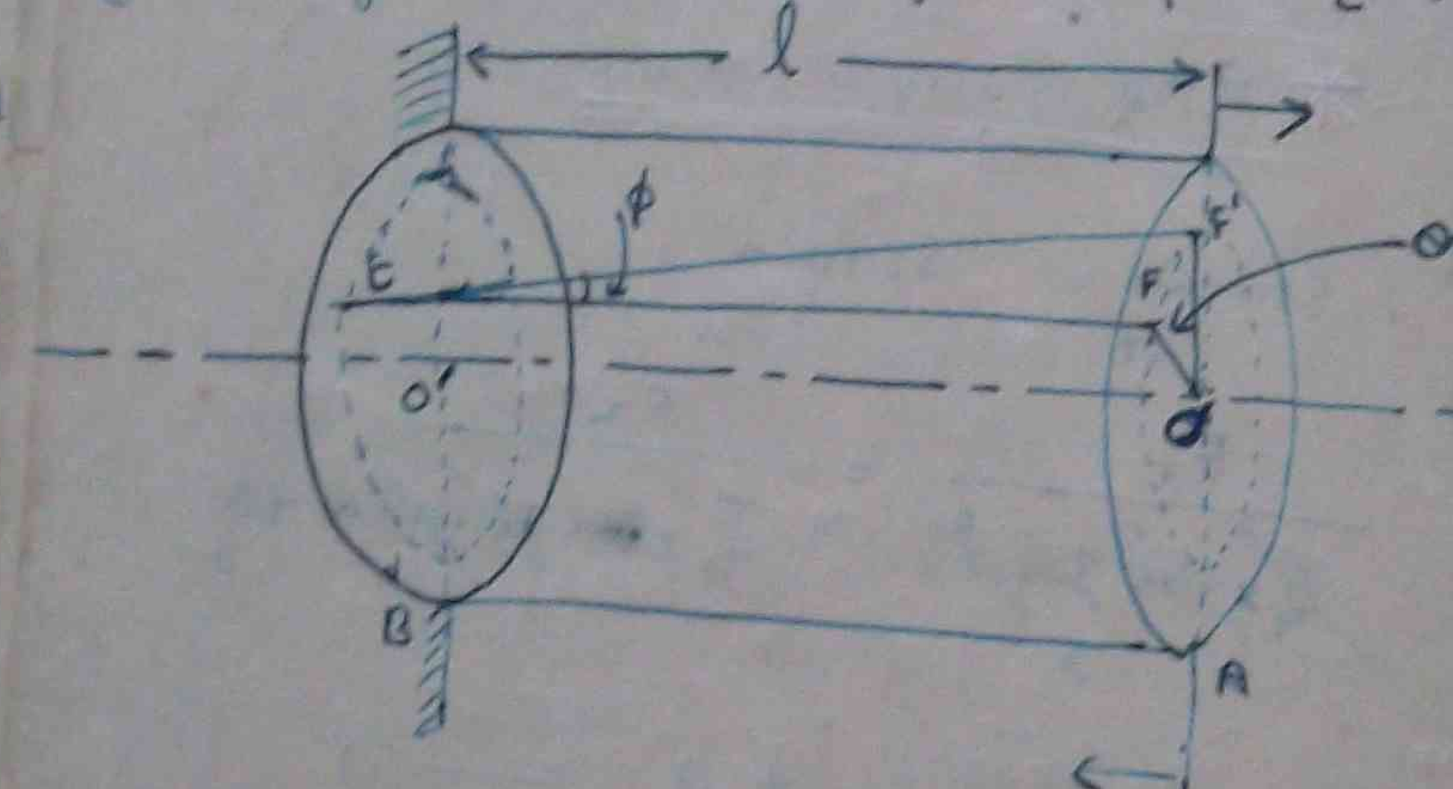
$$\therefore F = \frac{61550}{37.7} = 1635\ lb/in^2$$

$$\text{Strain} = \frac{1635}{16\times10^6} = 102\times10^{-6} = .000102$$ #

Torsion ([illegible])

[illegible] couple [illegible]

[illegible] (Shearing force) [illegible]



Shearing force due to torque

[illegible]

[illegible] Torque [illegible] velocity [illegible] constant angular [illegible] stress [illegible] strain [illegible]

[illegible] AB [illegible] OO' [illegible] axis [illegible] l [illegible] R [illegible] A [illegible] Torque [illegible]

[illegible] cylinder [illegible] cylinder [illegible] E F [illegible] Torque [illegible] axis [illegible] Torque [illegible] E F' [illegible]

[illegible] angle FEF' [illegible] radians [illegible] shear strain on the layer of radius (r) $= \frac{FF'}{l}$

angle $FOF' = \theta$ [illegible]

[illegible] $\theta = \frac{FF'}{r}$ [illegible] $FF' = r\theta$

$$\therefore \phi = \frac{r\theta}{l}$$

[illegible] modulus of rigidity,

q = shear stress [illegible]

$$\phi = \frac{q}{c}$$

$$\therefore q/c = \frac{r\theta}{l}$$

([illegible]) $q/r = \frac{c\theta}{l}$ —— (1)

[illegible] shaft [illegible] shear stress [illegible] shaft axis [illegible] shaft [illegible]

[illegible] $r = R$

[illegible] shear stress [illegible]

$$\frac{q}{r} = \frac{Q}{R} = \frac{c\theta}{l}$$

θ [illegible] angle of twist [illegible]

[illegible]

*

$$HP = \frac{2\pi NT}{33000} \quad \text{—— (1)}$$

$$T = \frac{\cancel{\text{dia of shaft}}\ 2 \times q}{D} \times \frac{\pi D^4}{32} \quad \text{—— (2)}$$

[illegible]

$q = lb/in^2$

$T = lb\text{-}in$

$D = in$

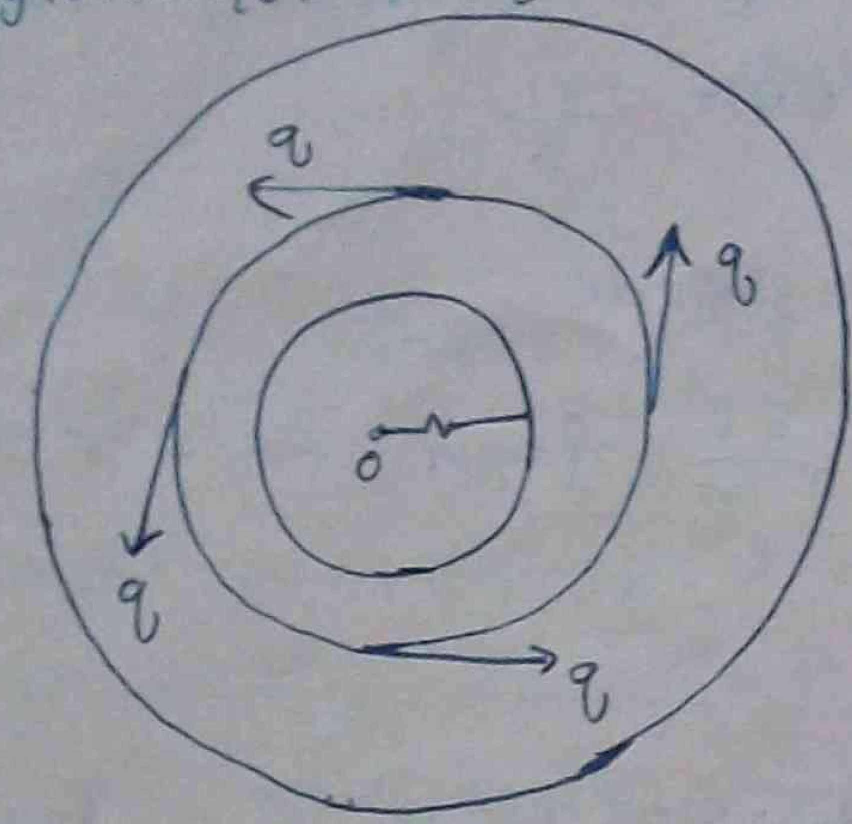
$N = rpm$

q = shear stress

ဝင်ရိုး တွင်ဖြစ်ပေါ်သော sheering force သည် ဝင်ရိုး သည် Tor-

T အား ပေးသွင်းခြင်းကြောင့် နှင့် ~~Torque~~ Torque နှင့် သန့် ... သည့် ...

sheering force ကိုဖော်ပေသည်။



ဝင်ရိုး၏ cross section ပေါ်တွင် အချင်းဝက် (r) နှင့် ...

δa ရှိသော Elementry ring တခုအားစဉ်းစားလျှင် $\frac{q}{r} = \frac{C\theta}{l}$

(or) $q = \frac{C\theta r}{l}$

Total shear force on the ring $= \frac{C\theta r\,\delta a}{l}$

moment of this force about the axis $= \frac{C\theta r^2\,\delta a}{l}$

$\therefore$ Total moment of Resistance T is given by

$$T = \sum \frac{C\theta r^2 \delta a}{l} = \frac{C\theta}{l} \sum r^2 \delta a$$

$\sum r^2 \delta a$ သည် ... ၏ moment of Inertia ဖြစ်သည် နှင့် Polar moment of Inertia ဟုခေါ်၍ ၎င်းကို J ဖြင့်သင်္ကေတပြုသည်။

$\therefore T = \frac{C\theta}{l} \times J$

or $\frac{T}{J} = \frac{C\theta}{l}$

Eq ① နှင့် ... Equation ကို ပေါင်းသော်—

$$\frac{q}{r} = \frac{Q}{R} = \frac{T}{J} = \frac{C\theta}{l} \quad \text{——— (II)}$$

ထို့ကြောင့် $T = Q \times \frac{J}{R}$

J/R ကို polar modulus of section ဟုခေါ်၍ အချင်း D ရှိသော အစိုင်ဝင်ရိုးအတွက်မှာ:—

$$J = \frac{\pi}{32} D^4$$

$$\therefore \frac{J}{R} = \frac{\pi}{32} D^4 \div \frac{D}{2} = \frac{\pi}{16} D^3$$

$$\therefore T = Q \frac{\pi}{16} D^3$$

အတွင်းအချင်း d အပြင်အချင်း D ရှိသော ခေါင်းပွဝင်ရိုးအတွက်

$$J = \frac{\pi}{32} (D^4 - d^4)$$

$$\frac{J}{R} = \frac{\pi}{32} (D^4 - d^4) \div \frac{D}{2}$$

$$= \frac{\pi}{16} \times \frac{(D^4 - d^4)}{D}$$

$$\therefore T = Q \times \frac{\pi}{16} \cdot \frac{D^4 - d^4}{D}$$

ထို့ပြင် θ သည် $\frac{T}{J} = \frac{C\theta}{l}$

$$\therefore \theta = \frac{Tl}{CJ}$$

Shaft ၏ H.P

အကယ်၍ Shaft သည် N အကြိမ်လည်၍ Torque T ကိုပေးလျှင် work done/min = Torque × angler displacement/min

$$= T 2\pi N = 2\pi N T$$

$$\therefore HP = \frac{2\pi N T}{33000}$$

$$T = \frac{Q \times J}{R} = \frac{J C\theta}{l} = \frac{198000\,HP}{N\pi}$$

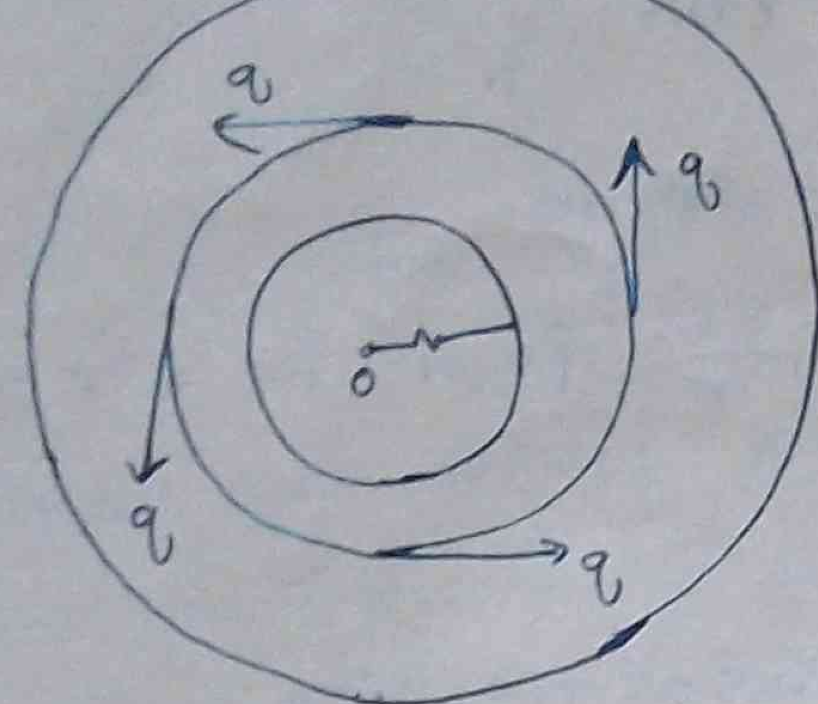
$$\therefore \boxed{T = \frac{198000 \times HP}{N\pi}}$$

T = Torque

HP = Horse power

moment of Resistance

ဝင်ရိုးတွင် ဖြစ်ပေါ်သော shearing force သည် ဝင်ရိုးသည့် Torque T ~~အား~~ ပေးနိုင်ခြင်းကြောင့် ၎င်း ~~Torque~~ Torque နှင့် တန်းတူသည့် ရုန်းအား shearing force ကိုပေါ်စေသည်။



ဝင်ရိုး၏ အချင်း၏ cross section ပေါ်တွင် အချင်းဝက် (r) နှင့် area δa ရှိသော Elementry ring တစ်ခုကို စဉ်းစားလျှင် $\frac{q}{r} = \frac{c\theta}{l}$

(or) $q = \frac{c\theta r}{l}$

Total shear force on the ring $= \frac{c\theta r\,\delta a}{l}$

moment of this force about the axis $= \frac{c\theta r^2\,\delta a}{l}$

∴ Total moment of Resistance T is given by

$$T = \Sigma \frac{c\theta r^2 \delta a}{l} = \frac{c\theta}{l}\,\Sigma r^2 \delta a$$

$\Sigma r^2 \delta a$ သည် ဖြတ်ပိုင်း၏ ဝင်ရိုးနှင့်ပတ်သက်၍ moment of Inertia ဖြစ်သည် ၎င်း Polar moment of Inertia ဟုခေါ်ပြီး ၎င်းကို J ဖြင့် ဖော်ပြသည်။

$$\therefore T = \frac{c\theta}{l} \times J$$

$$\text{or } \frac{T}{J} = \frac{c\theta}{l}$$

Eq ① နှင့် ပေါင်းလျှင် Equation ရ. ပေါင်းရသော —

$$\frac{q}{r} = \frac{Q}{R} = \frac{T}{J} = \frac{c\theta}{l} \quad \text{——— (11)}$$

ဆိုခဲ့ပြီးလျှင် $T = Q \times \frac{J}{R}$

J/R ကို polar modulus of section ဟုခေါ်သည်။ အချင်း D ရှိသော ဝင်ရိုးအတွက်: —

$$J = \frac{\pi}{32} D^4$$

$$\therefore \frac{J}{R} = \frac{\pi}{32} D^4 \div \frac{D}{2} = \frac{\pi}{16} D^3$$

$$\therefore T = Q \frac{\pi}{16} D^3$$

အတွင်းအချင်း d နှင့် အပြင်အချင်း D ရှိသော ဝင်ရိုးခေါင်း အတွက်

$$J = \frac{\pi}{32} (D^4 - d^4)$$

$$\frac{J}{R} = \frac{\pi}{32} (D^4 - d^4) \div \frac{D}{2}$$

$$= \frac{\pi}{16} \times \frac{(D^4 - d^4)}{D}$$

$$\therefore T = Q \times \frac{\pi}{16} \cdot \frac{D^4 - d^4}{D}$$

ထို့ကြောင့် θ သည် $\frac{T}{J} = \frac{c\theta}{l}$

$$\therefore \theta = \frac{Tl}{cJ}$$

Shaft ၏ H.P

အကယ်၍ Shaft သည် N အကြိမ် Torque T ဖြင့် လည်လျှင် work done/min = Torque × angler displacement/min

$$= T\,2\pi N = 2\pi N T$$

$$\therefore HP = \frac{2\pi N T}{33000}$$

$$T = \frac{Q \times J}{R} = \frac{Jc\theta}{l} = \frac{193000\,HP}{N\pi}$$

$$\therefore \boxed{T = \frac{193000 \times HP}{N\pi}}$$

T = Torque
HP = Horse power
T = r/m

Torque = lb-ft

Prob (2)

[illegible] shaft [illegible] shear stress 5 tons/sq in [illegible] Torque (lb-ft) [illegible]

$$\frac{q}{r} = \frac{T}{J} \quad \text{and} \quad J = \frac{\pi}{32} D^4$$

$$T = \frac{2q}{D} \times \frac{\pi D^4}{32} = \frac{\pi D^3}{16} \times q$$

$$= \frac{\pi \times 2^3 \times 5}{16} = 2.5\pi \text{ ton-in}$$

$$= \frac{\pi \times 2.5 \times 2240}{12} \text{ lb-ft}$$

$$= \frac{5600\pi}{12} = 466.6\pi = 1465 \text{ lb-ft}$$

Prob (3) [illegible] shaft [illegible] r.p.m 500 [illegible]

$$HP = \frac{2\pi N T}{33000}$$

$$= \frac{2 \times \pi \times 500 \times 1465}{33000}$$

$$= \frac{\pi \times 1465}{33}$$

$$= \frac{4600}{33} = 140 \text{ HP}$$

Prob (3)

Shaft [illegible] 80 r.p.m [illegible] 25 HP [illegible] shaft [illegible] shear stress 6000 lb/in² [illegible]

HP = 25

N = 80

q = 6000 lb/in²

$$HP = \frac{2\pi N T}{33000}$$

T = ?

$$T = \frac{33000 \times HP}{2\pi N}$$

$$T = \frac{33000 \times 25}{2 \times \pi \times 80}$$

$$= \frac{825000}{503} = 1640 \text{ lb-ft}$$

$$\frac{q}{r} = \frac{T}{J} \quad \text{and} \quad J = \frac{\pi}{32} \times D^4 \qquad T = \frac{2q}{D} \times \frac{\pi D^4}{32}$$

$$\frac{2q}{D} = \frac{32T}{\pi D^4}$$

$$D = \sqrt[3]{\frac{16T}{\pi q}}$$

$$D = \sqrt[3]{\frac{16 \times 1640 \times 12}{\pi \times 6000}}$$

$$= \sqrt[3]{\frac{26240 \times 12}{18850}}$$

$$= \sqrt[3]{1.178 \times 12}$$

$$= 14.13^{.333}$$

$$D = 2.335''$$

(1) $HP = \frac{2\pi T N}{33000}$ T = lb-ft [illegible]

(2) $T = \frac{2q}{D} \frac{\pi D^4}{32}$ q = lb/in², T = lb-in, N = rpm

$T = \frac{2q}{D}\frac{\pi D^4}{32}$ = lb-in [illegible]

$HP = \frac{2\pi T N}{33000}$ [illegible]

① ဝင်ရိုးတံချောင်းသည် အပတ်ရေ 100 ဖြင့်လည်ပတ်၍ 50 HP ကို သယ်ပေးနိုင်ရမည်။
၎င်း shaft ၏ Twisting moment ကို in - lb ဖြင့်ရှာပါ။
၎င်း shaft ၏ stress သည် $\frac{9000}{q}$ lb/in² ဖြစ်လျှင် shaft ၏ အချင်းကို ရှာပါ။

② အချင်း 4" ရှိသော သံမဏိဝင်ရိုးတံချောင်းသည် အပတ်ရေ 220 ဖြင့်လည်ပတ်၍ 200 HP
ကိုသယ်ပေးနိုင်ပါက ၎င်း shaft ၏ (a) shear stress (b) shaft အလျားအချင်း 20.4 ...
အတွင်း ... ကို ရှာပါ $C = 12\times10^6$ lb/□"

① $N = 100$ Power = 50 HP Stress(q) = 9000 lb/in²

$$Hp = \frac{2\pi T N}{33000}$$

$$T = \frac{HP\times33000}{2\pi N} = \frac{50\times330\cancel{00}}{6.28\times1\cancel{00}} = \frac{16500}{6.28\times1.2} = \frac{2625}{1.2}\text{ lb} = 2190\text{ lb}$$

lb-in ဖြစ်သော = $2190\times12 = 26280$ lb-in $= \underline{26250 \text{ lb-in}}$ Ans①

$$\frac{q}{R} = \frac{T}{J} \quad\text{and}\quad J = \frac{\pi}{32}D^4$$

$$\therefore T = \frac{2q\pi D^4}{32D} \qquad 2q = \frac{32T}{\pi D^3}$$

$$D^3 = \frac{32T}{2\pi q}$$

$$D^3 = \frac{32\times26280}{2\times\frac{22}{7}\times9000}$$

$$= \frac{32\times26280\times7}{2\times22\times9000}$$

$$= \frac{224\times26280}{3960\cancel{0}} = \frac{7060\cancel{0}}{396\cancel{0}} = 17.87$$

$$D = 17.88^{.333} = \underline{\underline{2.458''}}$$

Ans②

②

$$Q = \frac{198000\ HP/R}{\pi NJ}$$

(a) $Q = \dfrac{198000\times200\times2\times32}{\pi\times220\times\pi\times4^4}$

(b) $\theta = \dfrac{19800\ HL}{\pi NCJ} = \dfrac{198000\times200\times20.4\times32}{\pi^2\ 220\times4^4\times12\times10^6}$ radian

(a) $Q = \dfrac{198000\times200\times2\times32}{\pi\times220\times\pi\times4^4}$

$$= \frac{396.000000\times64}{691\times256\times\pi}$$

$$= \frac{2535.000000}{177000\ \pi}$$

$$= \frac{2535\times10^6}{556\times10^3}$$

$$= \frac{2535}{556}\times10^3 = 4.56\times10^3 = 4560$$

(b) $\theta = \dfrac{198000\times HL}{\pi NCJ}$

$\boxed{20\times4 = \frac{204}{2.55}}$

$$= \frac{198000\times200\times20\times4\times32}{\pi^2\times220\times4^4\times12\times10^6}$$

$$= \frac{396\times10^5\times6528}{9.87\times2640\times256\times10^6\times2.55}$$

$$= \frac{2585\times10^3\times10^5}{26050\times256\times10^6\times2.55}$$

$$= \frac{2585\times10^8}{2.55\times667\times10^4\times10^6} = \frac{2585}{667\times2.55}\times10^{-2}$$

$= .015\times57.3$ deg

(3) [illegible] 4" [illegible] (solid shaft) [illegible] 27500 lb-in Torque [illegible] shaft [illegible] Torque [illegible] Hollow shaft [illegible] (Hollow shaft) [illegible] shaft [illegible]

20' [illegible]

Shaft [illegible]

$$C = 12\times10^6 \ lb/\square''$$

$D = 4''$ $R = 2''$ $T = 27500$ lb-in

$$\text{Shear stress} = q = \frac{TR}{J} = \frac{27500\times32\times2}{\pi\times4^4} = \frac{27500\times64}{\pi\times256_4}$$

$$= \frac{27500}{12.58} = 2190 \ lb/\square''$$

[illegible] 20' [illegible] $C = 12\times10^6 \ lb/\square''$ $q = 2190$

$l = 20\times12 = 240''$ $R = 2''$

$$\theta = \frac{ql}{RC}$$

$$= \frac{2190\times240}{2\times12\times10^6}$$

$$= \frac{525600}{24\times10^6} = \frac{5256}{24\times10^4} = \frac{219}{10^4} = .0219 \text{ radian}$$

$= .0219\times57.3 = 1.255$ degree

[illegible] $E\alpha t A$ - [illegible]

[illegible] $[E\alpha t$ - [illegible]$] = f_2$

$x = \frac{f_2 L}{E}$

$x_t = \frac{FL_A}{E_A A_A} + \frac{FL_B}{E_B A_B}$

$\delta_T = \frac{PL}{AE} + \frac{WL}{2AE}$

Hollow Shaft

$$\frac{T}{J} = \frac{q}{R}$$

$$\therefore \frac{J}{R} = \frac{T}{q}$$

$$\frac{\pi(D^4-d^4)}{16D} = \frac{T}{q}$$

$D = 2d$

$$\frac{(2d)^4-d^4}{2d} = \frac{16T}{\pi q}$$

$$d^3 = \frac{2\times16\times27500}{9\times15\times2190} = 2\tfrac{1}{16}''$$

$D = 4\tfrac{1}{8}''$

Hollow Shaft

$J = \frac{\pi}{32}(D^4-d^4)$

D = [illegible]

d = [illegible]

$A = \frac{\pi}{4}(D^2-d^2)$

(1) $HP = \frac{2\pi TN}{33000}$ (T = lb-ft)

(2) $q/R = T/J$

(3) $T = \frac{2q\pi D^4}{32D}$ (T = lb-in)

(4) $J = \frac{\pi}{32}\times D^4$ D = in

(5) maximum Shearstress $Q = \frac{192000 HP\times R}{\pi N J}$

(6) [illegible], $\theta = \frac{192000 H\times L}{\pi N C J}$

(7) [illegible], $\theta = \frac{q\,l}{RC}$

q = stress

θ = shearstress radian $\times 57.3$ = degree

R = radius (in)

[illegible] / maximum shear stress = Q

Hollowshaft [illegible] $T = \frac{2q\pi(D^4-d^4)}{D}$

(1) Poission Ratio $= \frac{e_2}{e_1}$

unit shear stress or shear stress = q

(2) $\frac{f_c}{E_c} = \frac{f_i}{E_i}$

$\delta_t = L_1\alpha_1 t + L_2\alpha t$

(3) $\delta_t = \frac{PL_1}{AE_1} + \frac{PL_2}{AE_2}$

(4) [illegible] $f = \frac{F}{2A}$ $x = \frac{FL}{2AE}$

(5) $f = E\alpha t$

(6) $\delta = L\alpha t$

working stress = ultimate stress / Safety factor

ultimate strength = max load / ori A

Shear stress = $\frac{F}{\ldots}$

angle of twist at a length of 10' =

$q = 7170$ lb/in²

$l = 120''$

$R = 2\frac{1}{16}$

$C = 12 \times 10^6$ lb/in²

$= \frac{7170 \times 120}{2\frac{1}{16} \times 12 \times 10^6} = .0212$ radians

$= .0212 \times 57.3 = 1.215°$

$\frac{W_1}{W_2} = \frac{[illegible]}{[illegible]} = \frac{\frac{\pi}{4}\left((4\frac{1}{2})^2 - (2\frac{7}{16})^2\right)}{\frac{\pi}{4} \times 4 \times 4}$

$= \cdot 2 = 80\%$

Exercises

① [illegible] 165 R.P.M [illegible] 150 H.P [illegible] max. shear stress [illegible] 6400 lb/in² [illegible] 1° [illegible]

$d = 3.37''$ $d = 3.82''$

② [illegible] 2½" [illegible] 5000 500 lb [illegible]

$C = 5100$ tom/in²

2.75"

2.83"

① $N = 165$ RPM $q = 6400$ lb/in²

HP = 150

$q = \frac{198000\,HP\,R}{\pi N J}$ $J = \frac{\pi}{32} D^4$

$\frac{J}{R} = \frac{198000 \times HP}{\pi N q}$

$\frac{J}{R} = \frac{198000 \times 150}{\pi \times 165 \times 6400} = \frac{29700000}{518 \times 6400} = \frac{29700000}{3324000}$

$J/R =$ $= 8.95$

$\frac{J}{R} = \frac{\pi}{16} D^3$

$J = \frac{\pi}{32} D^4$

$J = \frac{\pi}{32} \times D^3 \times D$

$J = \frac{\pi}{32} \times D^3 \times 2 \times R$

$J/R = \frac{\pi}{16} D^3$

$8.95 = \frac{\pi}{16} D^3$

$\left(\frac{8.95 \times 16}{\pi}\right)^{.333} = D$

$\left(\frac{143.2}{\pi}\right)^{.333} = D$

$(45.6)^{.333} = D$

$D = 3.56''$

$\theta = 1°$

radian [illegible] $= \frac{1}{57.3}$ radian

$\theta = \frac{q\,l}{R\,C}$ $\theta = \frac{198000\,H\,l}{\pi N C J}$

$q/R = T/J$ $\frac{q\,l}{R\,C} = \frac{198000\,H\,l}{\pi N C J}$

[illegible] $\theta = \frac{198000 \times H\,l}{\pi N C J}$

$J/R = 8.95$

$J =$

$C = \frac{198000 \times H\,l}{\pi N \theta J}$

$C = \frac{198000 \times 150 \times 20 \times D}{\pi \times 165 \times \frac{1}{57.3} \times \frac{\pi}{32} D^4}$

$C = \frac{198000 \times 150 \times 20\,D \times 57.3 \times 32}{\pi \times 165 \times \pi \times D^4}$

$D^3 = \frac{198000 \times 150 \times 20 \times D \times 57.3 \times 32}{\pi \times 165 \times \pi \times C}$

$D^3 = \frac{198000 \times 150 \times 20 \times 57.3 \times 32}{\pi \times 165 \times \pi \times \frac{[illegible]}{[illegible]}}$

$\theta = \frac{q l}{Rc}$ $\quad q/R = \frac{T}{J}$

~~1 = 57 radians~~

1 radians = 57.3°

$\therefore 1° = \frac{1}{57.3}$ radians

$\theta = \frac{T}{J} \times \frac{l}{c}$ — ①

$\theta = 1° = \frac{1}{57.3}$ radians

$l = 20\text{D}$

$Hp = \frac{2\pi T N}{33000}$

$\therefore T = \frac{Hp \times 33000}{2\pi N} = \frac{150 \times 33000}{2 \times \pi \times 165} = \frac{150 \times \cancel{33000}^{100}}{\cancel{330} \times \pi} = \frac{15000}{\pi}$

lb-in ဖွဲ့သော် ⇒ $\frac{15000}{\pi} \times 12 = \frac{180000}{\pi} = 57300$ lb-in

$J = \frac{\pi}{32} D^4 =$

① တွင် အစားသွင်းသော် → $\frac{1}{57.3} = \frac{57300}{\frac{\pi}{32} \times D^4} \times \frac{20D}{12 \times 10^6}$

$\frac{1}{57.3} = \frac{57300 \times 32}{\pi \times D^3} \times \frac{20}{12 \times 10^6}$

$D^3 = \frac{57300 \times 57.3 \times 32 \times 20}{\pi \times 12 \times 10^6}$

$D^3 = \frac{328 \times 10^4 \times 640}{37.7 \times 10^6}$

$D^3 = \frac{328 \times 64}{3770} = \frac{21000}{3770} = 5.57$

$D = 5.57^{.333} = 3.82''$

② $l = 10' = 120''$ $\quad D = 2.5''$ $\quad C = 5200$ ton/in²

$C = 5200 \times 2240$ lb/in²

$C = 1165 \times 10^4$ lb/in²

Torque $= 500 \times 3 \times 12 = 18000$ lb-in

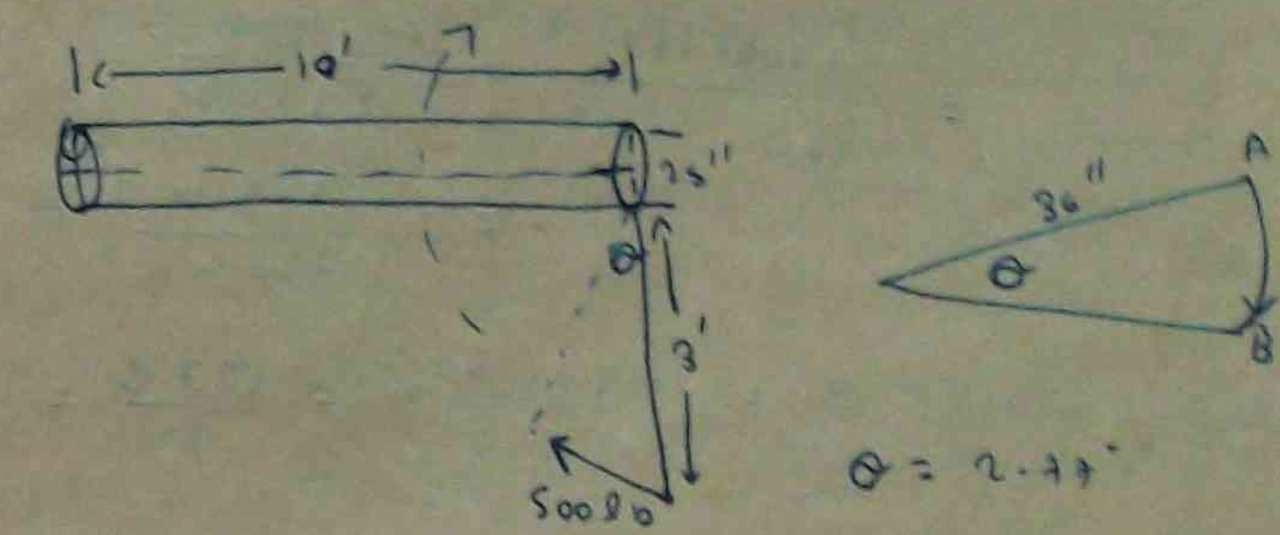
$\theta = \frac{q l}{Rc} = T$

$= \frac{T}{J} \times \frac{l}{c} =$

$= \frac{18000 \times 120''}{\frac{\pi}{32} \times (2.5)^4 \times 1165 \times 10^4}$

$= \frac{\cancel{69}\ 216 \times 32}{39.05 \times 3.60} = \frac{681}{14300}$ radians

degree ဖွဲ့သော် $= \frac{681 \times 57.3}{14300} = \frac{34000}{14300} = 2.77°$



$\theta = 2.77°$

ဘ: ... $= AB$

$AB = \frac{\theta}{360} \times 2\pi r$

$= \frac{2.77}{360} \times 2 \times 3.14 \times 36$

$= \frac{2.77 \times 6.28}{10} = 2.77 \times .628 = 1.75''$

အရှည် 15' အချင်း 3" ရှိ ... 1 minute လျှင် အပတ်ရေ 100 ဖြင့် ... 20 ... C = 5200 tons/in² ဖြစ်လျှင် ...

$T =$ $\quad Hp = \frac{2\pi T N}{33000}$

$T = \frac{Hp \times 33000}{2\pi N}$

$T = \frac{20 \times 330\cancel{00}}{2 \times 3.14 \times 1\cancel{00}} = \frac{6600}{6.28} = 1050$ lb-ft

lb-in ဖွဲ့သော် $= 1050 \times 12 = 12600$ lb-in

$\therefore T = 12600$ lb-in

$$J = \frac{\pi}{32} D^4$$

$$= \frac{\pi}{32} \times (3)^4 = \frac{\pi \times 81}{32} = \frac{254.5}{32} = 7.95$$

$$\theta = \frac{q\,l}{R.C} \qquad \frac{q}{R} = \frac{T}{J}$$

$$C = 5200 \ ton/in^2$$
$$= 5200 \times 2240 \ lb/in^2$$
$$= 1165 \times 10^4 \ lb/in^2$$

$$\theta = \frac{T}{J} \cdot \frac{l}{C}$$

$$= \frac{12600}{7.95} \times \frac{15 \times 12}{1165 \times 10^4}$$

$$= \frac{12600 \times 180}{9260 \times 10^4} = \frac{2268000}{926 \times 10^5}$$

$$= \frac{2268 \times 10^3}{926 \times 10^5} = \frac{2.45}{100} \text{ radians}$$

degree ပြောင်းသော် $\theta = \frac{2.45 \times 57.3}{100} = \frac{137.8}{100} = 1.378°$

$$q = \frac{198000 \ HP \ R}{\pi N J}$$

$$= \frac{198000 \times 20 \times 1.5}{\pi \times 100 \times 7.95}$$

$$= \frac{1980 \times 30}{24.98} = \frac{59400}{22.98} = 2380 \ lb/in^2$$

1 minute လျှင် အပတ်ရေ 100 ပတ် ဖြင့် မြင်းကောင်ရေအား 200 ကို သယ်ဆောင်နိုင်ရန် ဝင်ရိုး၏ အချင်း မည်မျှရှိရမည်နည်း။ ခံနိုင်သော ကျောဖြတ်အား သည် 9000 lb/in² ဖြစ်ပါသည်။

max: stress

N = 200 r.p.m $\qquad q = 9000 \ lb/in^2 \qquad D = ?$

HP = 200

$$q = \frac{198000 \ HP \ R}{\pi N J} \qquad \therefore \frac{J}{R} = \frac{396}{9\pi}$$

$$9000 = \frac{198000 \times 200 \ R}{\pi \times 100 \ J} \qquad \frac{J}{R} = \frac{44}{\pi}$$

$$9 = \frac{396}{\pi} \cdot \frac{R}{J}$$

$$\frac{\pi}{32} D^4 \times \frac{1}{R} = \frac{44}{\pi}$$

$$\frac{\pi}{32_{16}} \times D^4 \times \frac{2}{D} = \frac{44}{\pi}$$

$$\frac{\pi}{16} D^3 = \frac{44}{\pi}$$

$$D^3 = \frac{44 \times 16}{\pi^2}$$

$$D^3 = \frac{704}{9.87} = 71.3$$

$$D = 71.3^{.333} = 4.14''$$

ကွေးဆိုင်းနှင့် ကျောဖြတ်အား

Bending moment and Shearing force

တန်းတခုပေါ်တွင် ဝန်လိုက်ကျသည့်အခါ [illegible] Reaction [illegible] ပေါ်တွင် [illegible] တန်းသည် ဝန် [illegible] A [illegible] (clockwise) [illegible] A [illegible] (+) [illegible] A [illegible] ဖြစ်သည်။

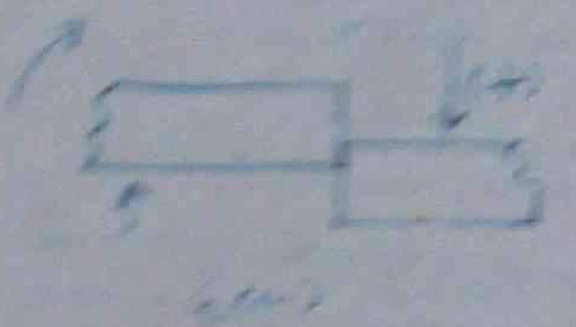
[illegible]

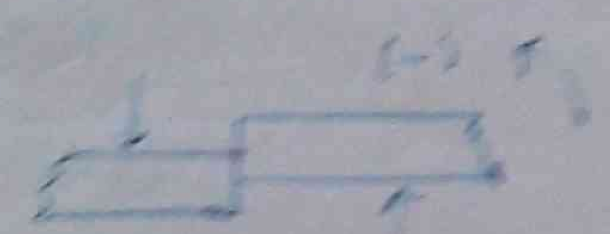
တန်း [illegible] ကွေးဆိုင်း [illegible]

Shearing force (ကျောဖြတ်အား)

တန်း [illegible] ကျောဖြတ်အား [illegible] positive shear

negative shear





positive bending moment

negative bending moment

Simply supported beam

Cantilevers

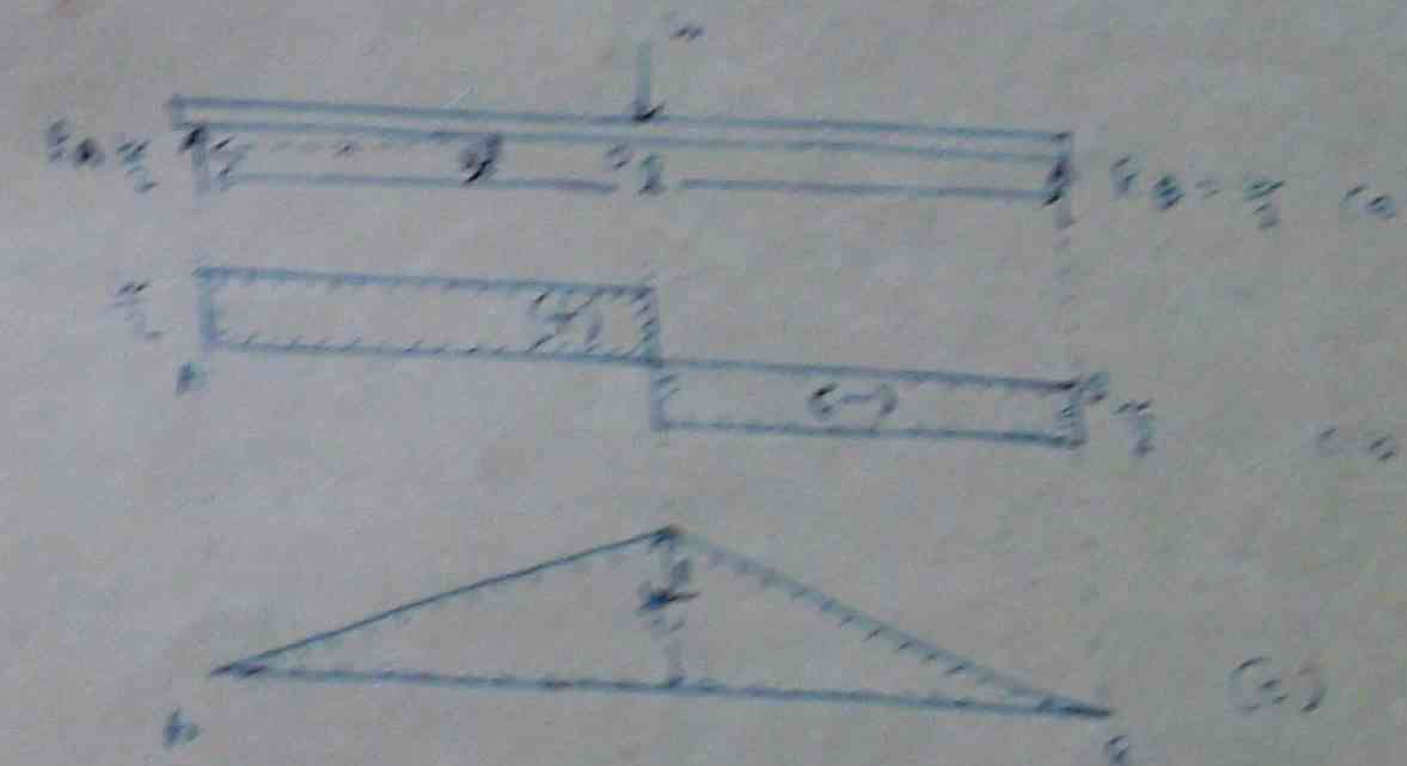
Beam with

concentrated load

distributed load

distributed and concentrated load

Simply supported beam carrying a point load at the middle point



$R_A = R_B = \frac{W}{2}$

Shearing force at A to C = $\frac{W}{2}$

C to B = $\frac{W}{2} - W = -\frac{W}{2}$

Shearing force diagram

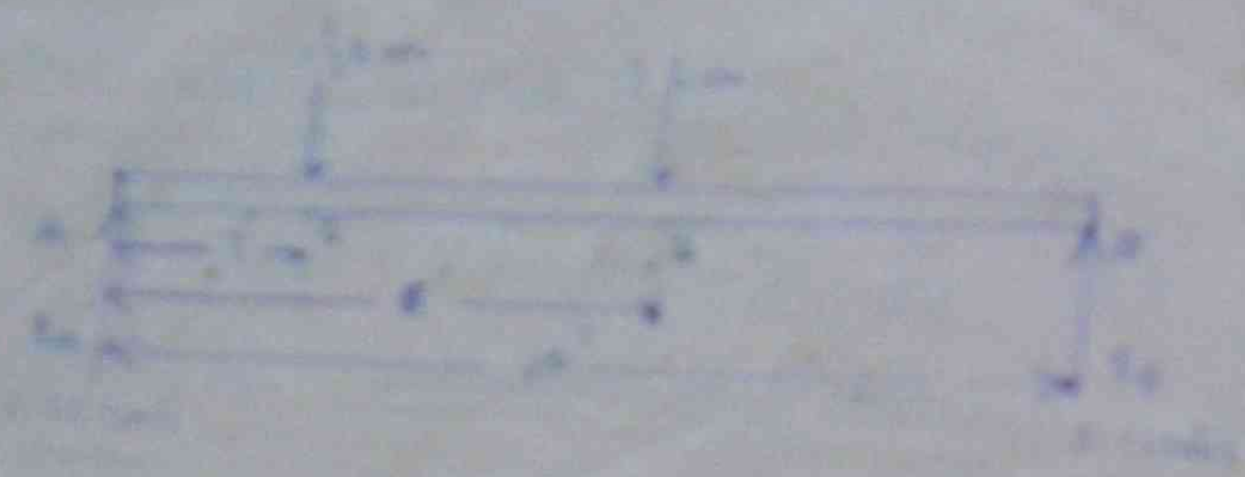
Bending moment at x = $\frac{W}{2} \cdot x$

at A = 0

at C = $\frac{W}{2} \times \frac{l}{2} = \frac{Wl}{4}$

maximum bending

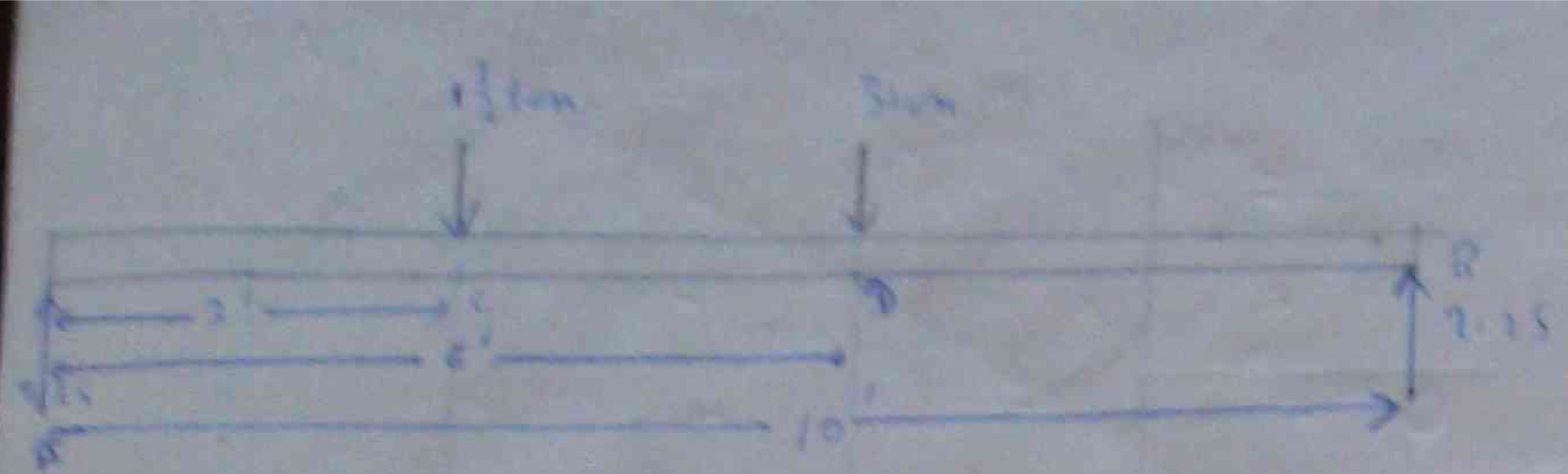
[illegible]



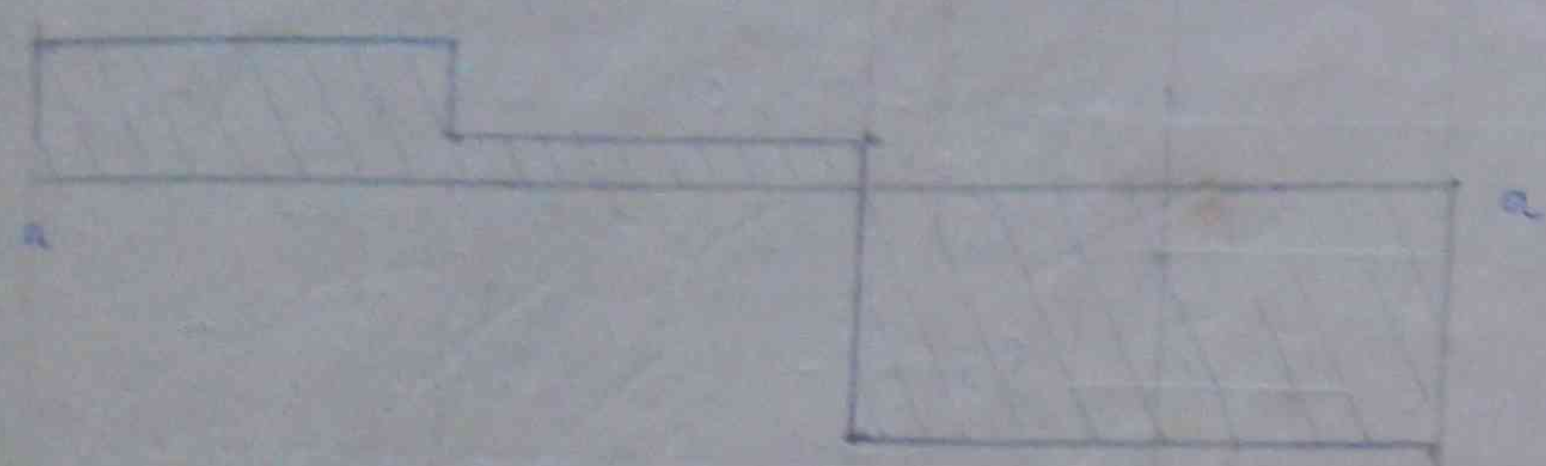
[illegible]

Position of sections		Bending moment at that section
At A	⟶	$R_A \times 0 = 0$
1ft from A	⟶	$R_A \times 1 = 2\frac{1}{4}$ ton ft
2ft from A	⟶	$R_A \times 2 = 2\frac{1}{4} \times 2 = 4\frac{1}{2}$ ton ft
At C	⟶	$R_A \times 3 - 1\frac{1}{2} \times 0 = 6\frac{3}{4}$ ton ft
At 1ft beyond C	⟶	$R_A \times 4 - 1\frac{1}{2} \times 1 = 7\frac{1}{2}$ ton ft
At 2ft beyond C	⟶	$R_A \times 5 - 1\frac{1}{2} \times 2 = 8\frac{1}{4}$ ton ft
At D	⟶	$R_A \times 6 - 1\frac{1}{2} \times 3 - 3 \times 0 = 9$ ton ft
At 2ft beyond D	⟶	$R_A \times 8 - 1\frac{1}{2} \times 5 - 3 \times 2 = 4\frac{1}{2}$ ton ft
At E	⟶	$R_A \times 10 - 1\frac{1}{2} \times 7 - 3 \times 4 = 0$

[illegible]



Linear
Scale = 5 : 1

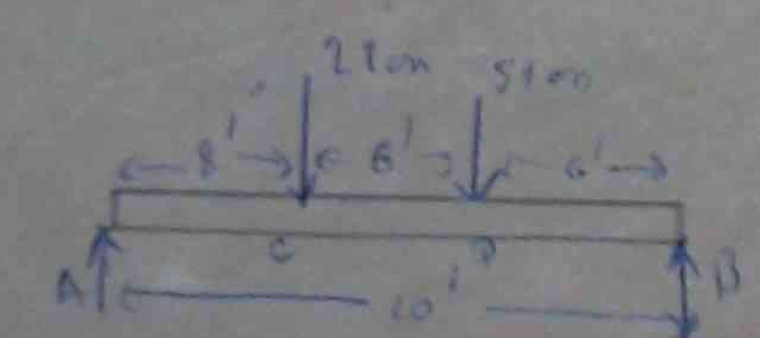


SF diagram

a' bending moment diagram

Exercise

1. [illegible] shear force [illegible] bending moment [illegible] shearing force and bending moment diagram [illegible]



$8 = \frac{86}{20} = 4.3$ tons

moment at B

$20A = 2 \times 12 + 5 \times 6$

$A = \frac{54}{20} = 2.7$ tons

At A = 2.7 tons upward

Right of A = 2.7 tons (")

Left of C = 2.7 tons (")

at C = 2.7 − 2 = .7 tons

Right of C = 2.7 − 2 = .7 tons

Left of D = 2.7 − 2 = .7 ton "

At D = 2.7 − (5 + 2) = +4.3 tons (downward)

At Right of D = 2.7 − (5 + 2) = +4.3 tons "

Left of B = 2.7 − (5 + 2) = +4.3 tons "

At B = 2.7 − (5 + 2) = +4.3 tons "

At A = 2.7 × 0 = 0 ——— At A

~~At~~ Ay 1' = 2.7 × 1 = 2.7 ton ft

Ay 2' = 2.7 × 2 = 5.4 tons ft

Ay 3' = 2.7 × 3 = 8.1 " 2.7 8.9

Ay 4' = 2.7 × 4 = 10.8 "

Ay 5' = 2.7 × 5 = 18.5 "

Ay 6' = 2.7 × 6 = 16.2 "

Ay 7' = 2.7 × 7 = 18.9 "

Ay 8' = 2.7 × 8 − 2 × 0 = 21.6 " ——— At C

Ay 9' = 2.7 × 9 − 2 × 1 = 22.3 "

Ay 10' = 2.7 × 10 − 2 × 2 = 23 "

Ay 11' = 2.7 × 11 − 2 × 3 = 23.7 7.8.9

Ay 12' = 2.7 × 12 − 2 × 4 = 24.4 "

Ay 13' = 2.7 × 13 − 2 × 5 = 25.1 "

Ay 14' = 2.7 × 14 − 2 × 6 − 5 × 0 = 25.8 " ——— At D

Ay 15' = 2.7 × 15 − 2 × 7 − 5 × 1 = 21.5 "

Ay 16' = 2.7 × 16 − 2 × 8 − 5 × 2 = 17.2 " 4.3

Ay 17' = 2.7 × 17 − 2 × 7 − 5 × 3 = 16.9 "

Ay 18' = 2.7 × 18 − 2 × 8 − 5 × 4 = 12.6

Ay 19' = 2.7 × 19 − 2 × 9 − 5 × 5 = .87

Ay 20' = 2.7 × 20 − 2 × 10 − 5 × 6

A မှ 17' $2.7\times17 - 2\times9 - 5\times3 = 12.9$ ton-ft

A မှ 18' $2.7\times18 - 2\times10 - 5\times4 = 8.6$,,

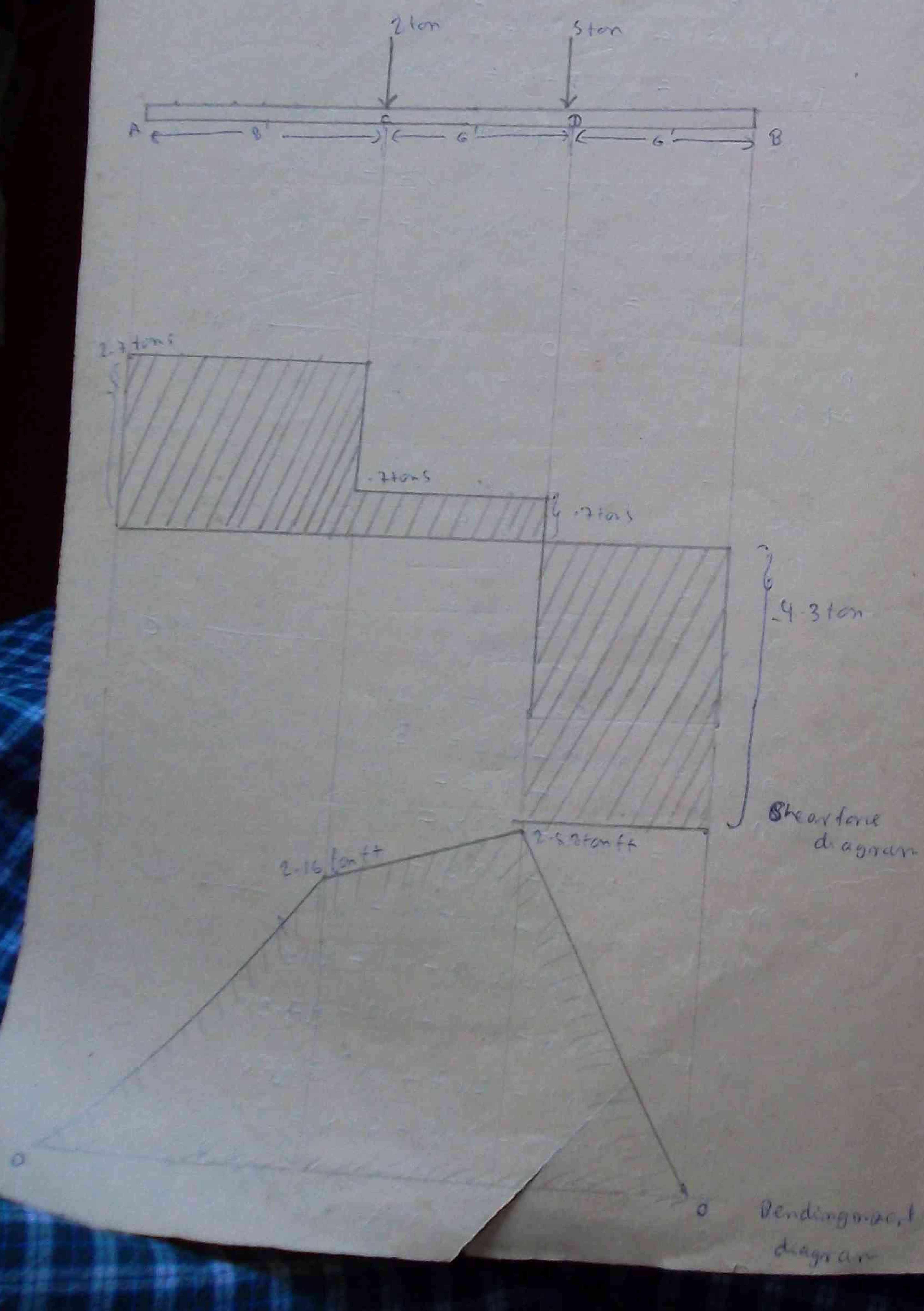
A မှ 19' $2.7\times19 - 2\times11 - 5\times5 = 4.3$

A မှ 20' $2.7\times20 - 2\times12 - 5\times6 = 0$,, —— A+B

Linear scale = .25" = 1'

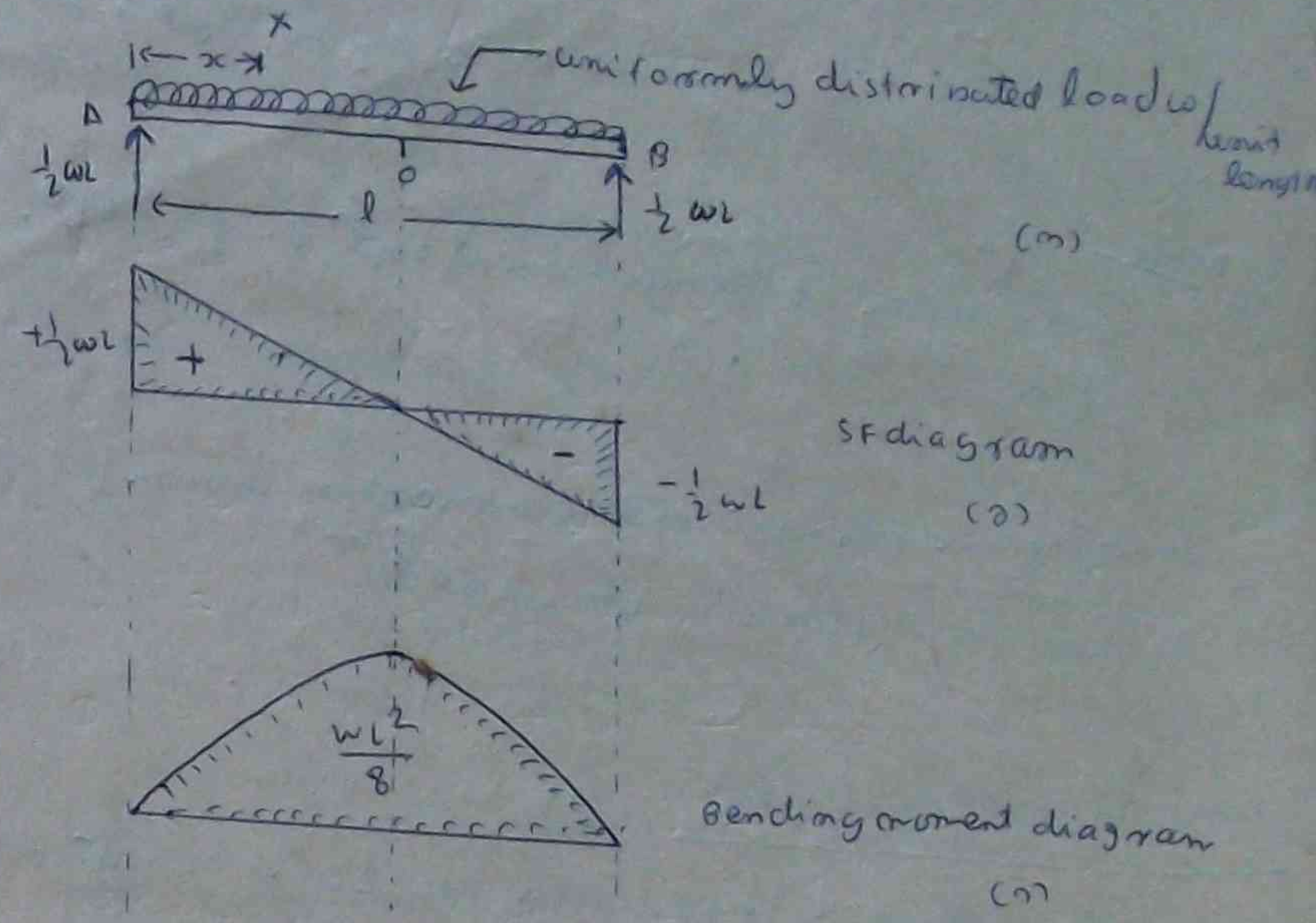
Shear force scale 2 tons = 1"

BM dia scale 10 ton = 1"



Uniformly Distributed load

ဖြန့်ဝန်လေးကောင်းသောတန်း



AB သည် တန်းတစ်ခုဖြစ်ပြီး ဝသည် တန်း၏ ... ဖြစ်သည်။ ယင်းသည် /unit length ဝန်လေး ဖြစ်သည်။

စုစုပေါင်းဝန် $W = \omega L$

$R_A = R_B = \frac{1}{2}\omega l$

အစွန်း A မှ x အကွာအဝေးတွင် X သည် section တစ်ခု ဖြစ်ပါစေ

A x အကြားရှိဝန် $= \omega x$

SF at $X = R_A - \omega x = \frac{1}{2}\omega L - \omega x$

ဤသည် 1st degree expression ဖြစ်သဖြင့် SF diagram သည် မျဉ်းဖြောင့် ဖြစ်သည်။

SF at A (when $x = 0$) $= \frac{1}{2}\omega l$

,, O (when $x = \frac{l}{2}$) $= \frac{1}{2}\omega l - \frac{\omega L}{2} = 0$

,, B (when $x = l$) $: \frac{1}{2}\omega L - \omega L = -\frac{\omega L}{2}$

Shearing force diagram သည် ပုံ (ခ) အတိုင်း ဖြစ်သည်။

Bending moment

Bending moment at $X = R_A x - \omega x \times \frac{x}{2} = \frac{1}{2}\omega l x - \frac{1}{2}\omega x^2$

ဤသည် 2nd degree expression ဖြစ်၍ BM diagram သည် parabola ဖြစ်သည်။

Bending moment at A = Bending moment at B = 0

" $0 = \frac{1}{2}\omega l \cdot \frac{l}{2} - \frac{1}{2}\omega \left(\frac{l}{2}\right)^2 = \frac{\omega l}{8}$

" diagram သည် ပုံ (က) အတိုင်း ဖြစ်သည်။

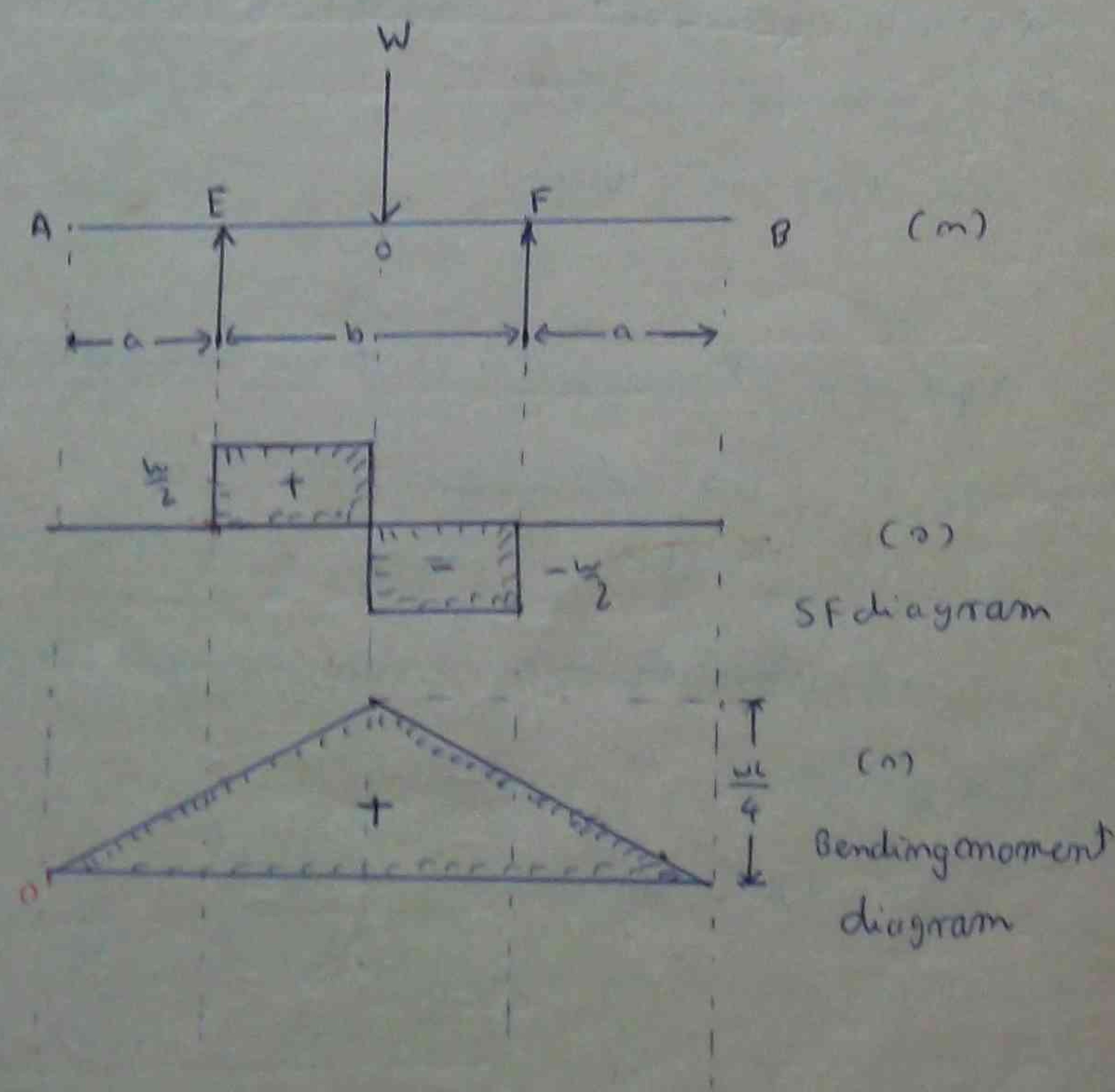
N.B

maximum Bending moment သည် ?-ရှိသည်။ $\frac{\omega l^2}{2}$ or $\frac{Wl}{8}$ ဖြစ်သည်။

Shearing force ၀ဖြစ်လျှင် Bending moment maximum ဖြစ်၍ bending moment ၀ဖြစ်လျှင် Shearing force maximum ဖြစ်ပါ

အစွန်းတူ ရှည်ထွက်ထားသော ဒမ်း

simply supported beam with equal overhang at both ends carrying a concentrated load at the middle point.



Reaction များ ဖြစ်သော E နှင့် F တို့သည် ထောက်များ ဖြစ်ပြီး W သည် ဝန် အလယ်တွင် ရှိသည်။

$R_E = R_F = \frac{W}{2}$

From A to E $S.F = 0$

" E to O $S.F = \frac{W}{2}$

" O to F $S.F = \frac{W}{2} - W = -\frac{W}{2}$

Shearing force diagram သည် ပုံ(ခ) အတိုင်း ဖြစ်သည်။

Bending moment

from A to E, $B.M = 0$

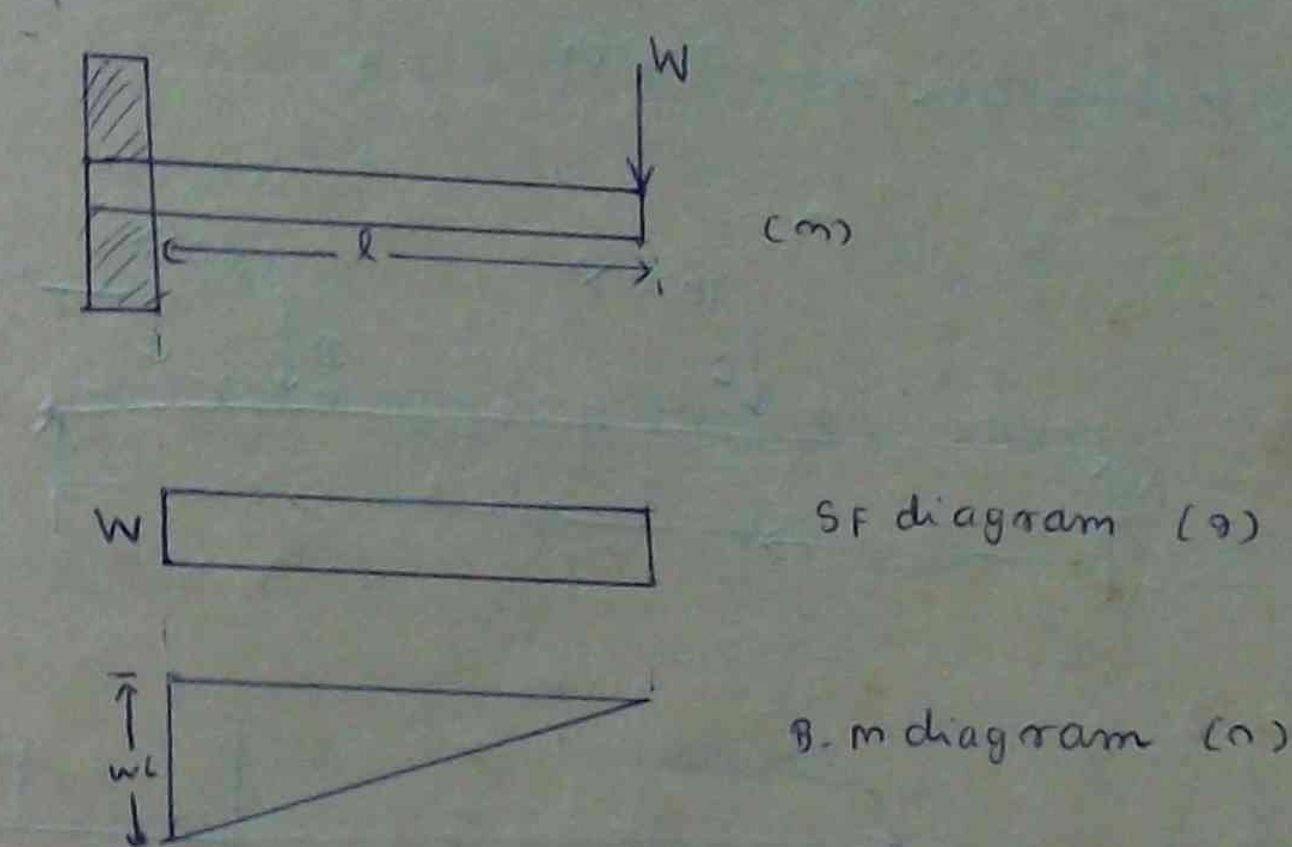
Bending moment at a distance x from E (between E and O) $= \frac{W}{2} x$

" at O $= \frac{W}{2} \times \frac{b}{2} = \frac{Wb}{4}$

B.M diagram သည် ပုံ(ဂ) အတိုင်း ဖြစ်သည်။

Cantilevers (တစ်ဖက်ချိတ်ဒမ်း များ)

တစ်ဖက်ချိတ်ဒမ်း ၏ အစွန်းတွင် ဝန်တစ်ခု သယ်ဆောင်ခြင်း



အစွန်းတွင် W ဖြစ်သော ဝန်ကြောင့် ... ဖြစ်ပါ၏။

... W ဖြစ်သည်။

... ဖြစ်ပါသည်။

ကွေးအား (bending moment)

... အကွာအဝေး

တွင် ကွေးအား $= W \times l$

အလျား x အကွာတွင် ကွေးအား $= W \times x$

အစွန်းတွင် ကွေးအား $= W \times l$

W သည် အမြဲ ကွေးအား ဖြစ်ပါ။ ကွေးအား ...

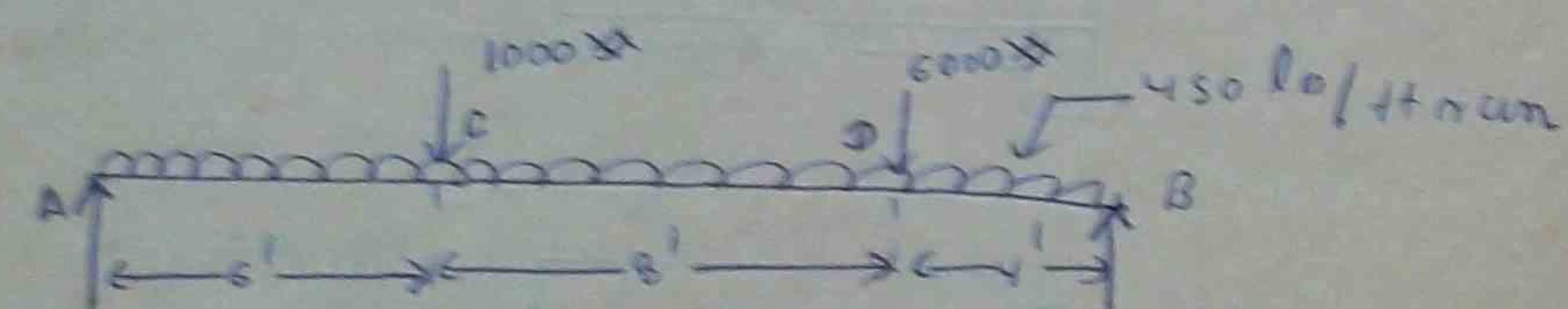
... ဖြစ်ပါသည်

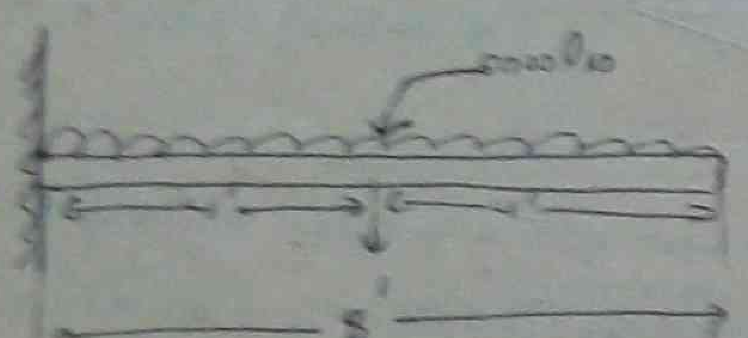
(၃) [illegible] 6000 lb [illegible] shear forces နှင့် bending moment [illegible] S. F နှင့် B. M diagram [illegible] scale [illegible]

(6000, 24000)

(၄) [illegible] 12' [illegible] beam [illegible] 4 cwt / ft [illegible] shear force [illegible] B. M [illegible] Ton in. unit [illegible] diagram [illegible] scale [illegible]

(၅) [illegible] S. F နှင့် B. M [illegible] S. F diagram နှင့် B. M diagram [illegible]

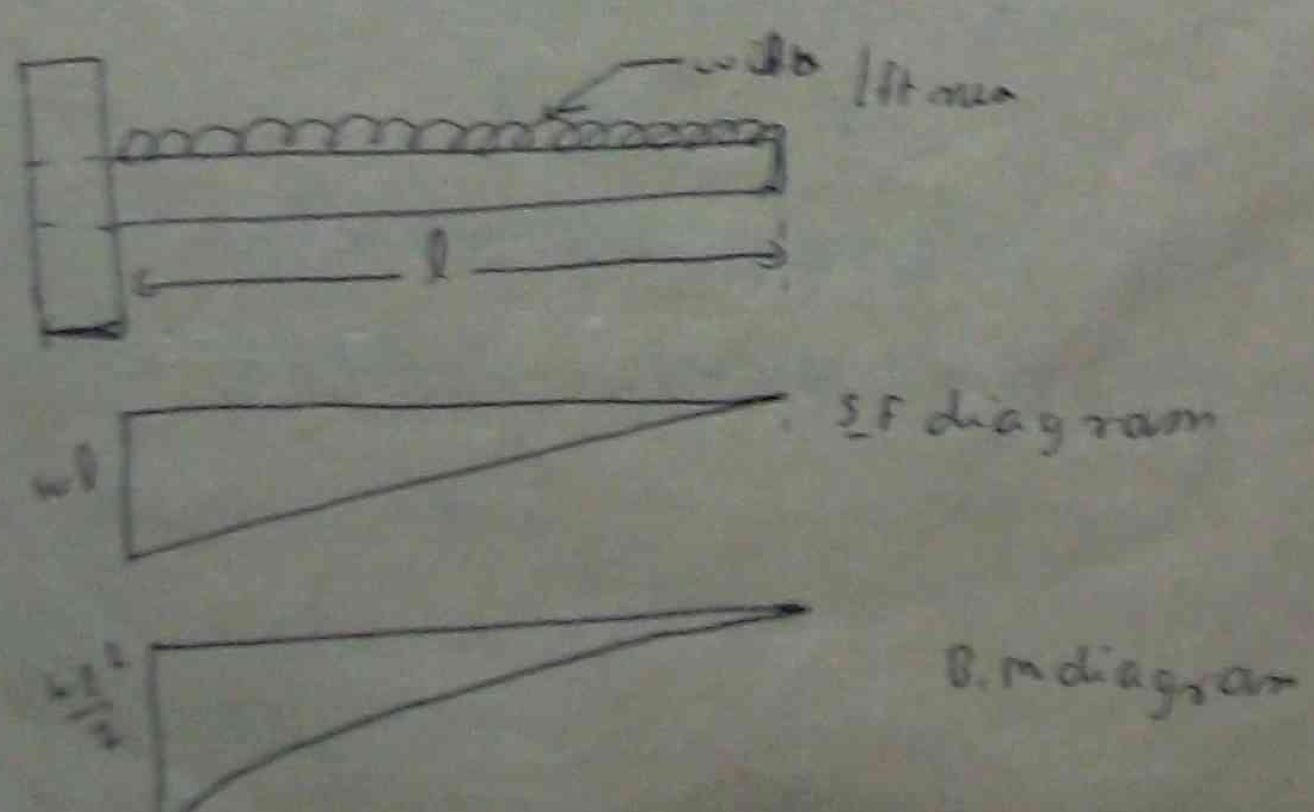




[illegible] 4' [illegible] $= 6000 \times 4 = 24000$ lb-ft

Shear force = 6000 lb

[illegible]



[illegible] w lb/ft [illegible]

[illegible] 1' [illegible] $= 1 \times w$

2' $= 2 \times w$

x $= x \times w$

l $= l \times w$

[illegible]

[illegible]

[illegible] $= w \times 1 \times \frac{1}{2}$

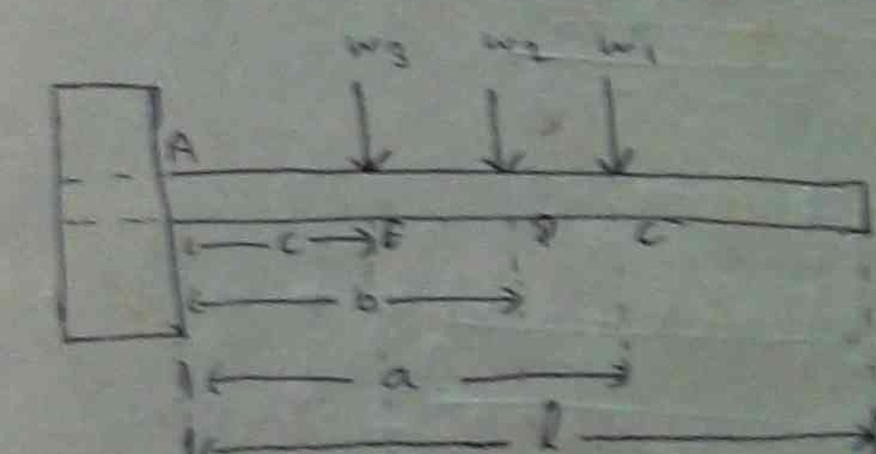
[illegible] 2' [illegible] $= w \times 2 \times \frac{2}{2}$

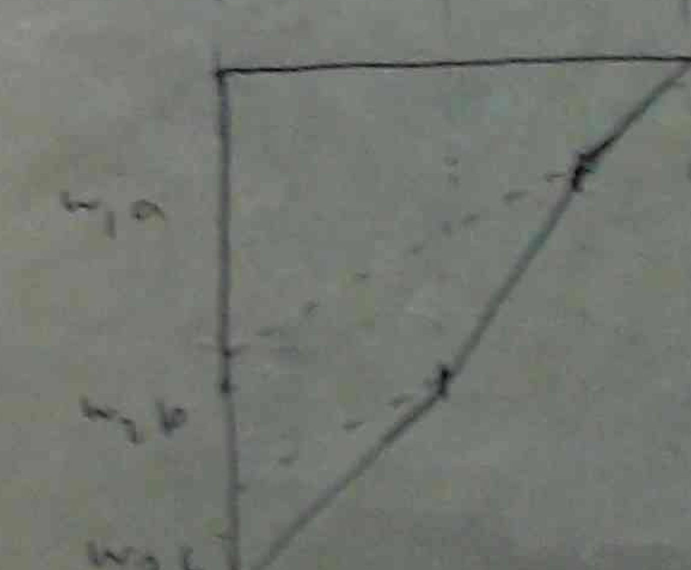
[illegible] x' [illegible] $= w \times x \times \frac{x}{2} = \frac{wx^2}{2}$

l $= w \times l \times \frac{l}{2} = \frac{wl^2}{2}$

[illegible] $\frac{wl^2}{2}$ [illegible] x^2 [illegible] parabola [illegible]

[illegible]





Shearing force

ဖြတ်အား ။ တန်းဘားရှိ a, b, c ကွာဝေးသော C, D, E တို့တွင် w_1, w_2, w_3 ဝန်များတင်ထားသည် CB အပိုင်းတွင်

တောင့်ဖြတ်အား မရှိသောကြောင့် ဖြတ်အား မရှိ ။

C D အပိုင်းတွင် ဖြတ်အား w_1 ဖြစ်၏ ။ D နေရာတွင် w_2 ထပ်မံလာသဖြင့်

D E အပိုင်းတွင် ဖြတ်အားသည် $w_1 + w_2$ ဖြစ်ပါ၏ ။ E တွင် w_3 ထပ်၍ သဖြင့်

EA တွင် ဖြတ်အားသည် $w_1 + w_2 + w_3$ ဖြစ်ပါ၏ ။

ကွေးအား Bending moment

CB အပိုင်းတွင် အားမရှိသဖြင့် ကွေးအား မရှိ

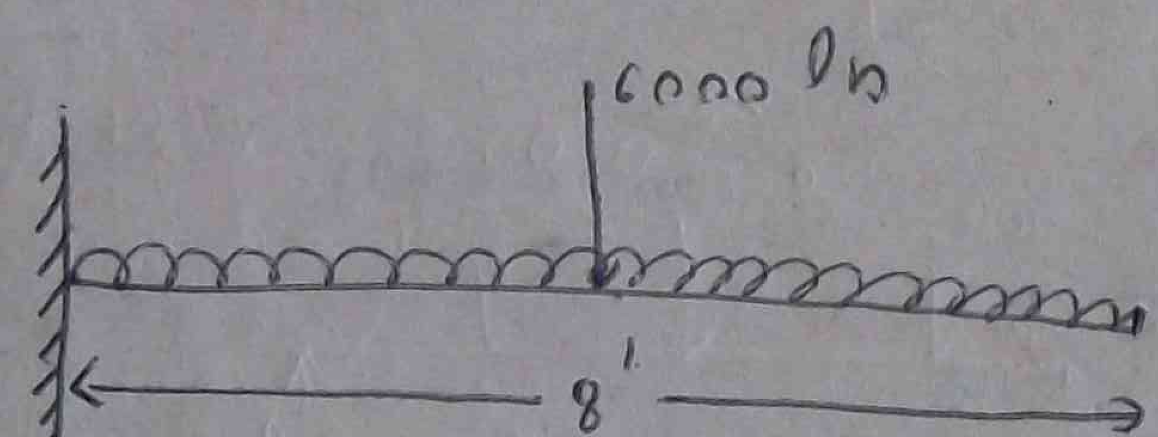
w_1 ဝန်ကြောင့် A တွင်ကွေးအား $= w_1 a$

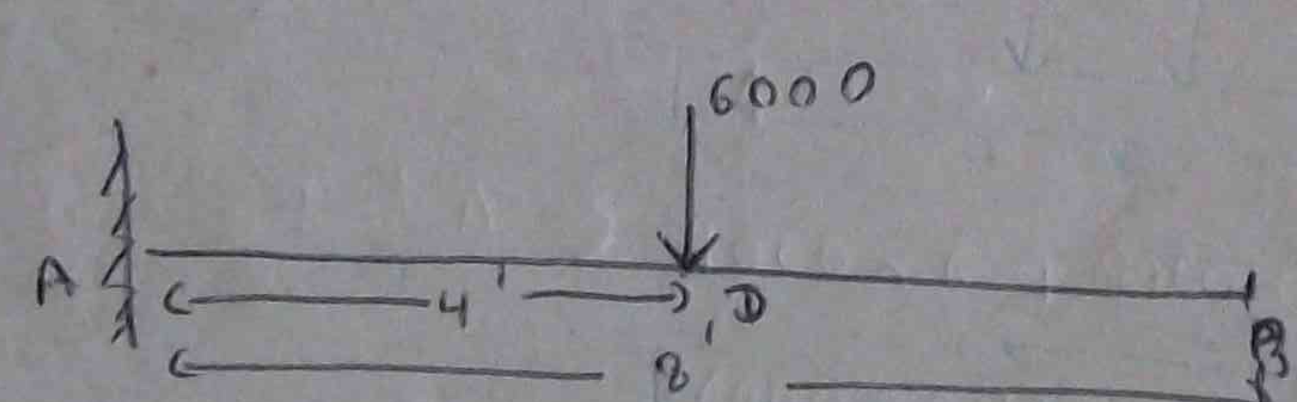
w_2 " " $= w_2 b$

w_3 " " $= w_3 c$

ယင်းကြောင့် A တွင်ကွေးအားသည် $w_1 a + w_2 b + w_3 c$ ဖြစ်၍ အကြီးဆုံးဖြစ်ပါ၏ ။

Prob (1)





Shearing force at D = 6000# (downward)

Bending moment at A = 6000 x 4 = 24000 lb-ft (downward)

Linear scale 1" = 4'

Shearing force scale 1" = 8000#

Bending moment scale = 2" = 24000# lb-ft

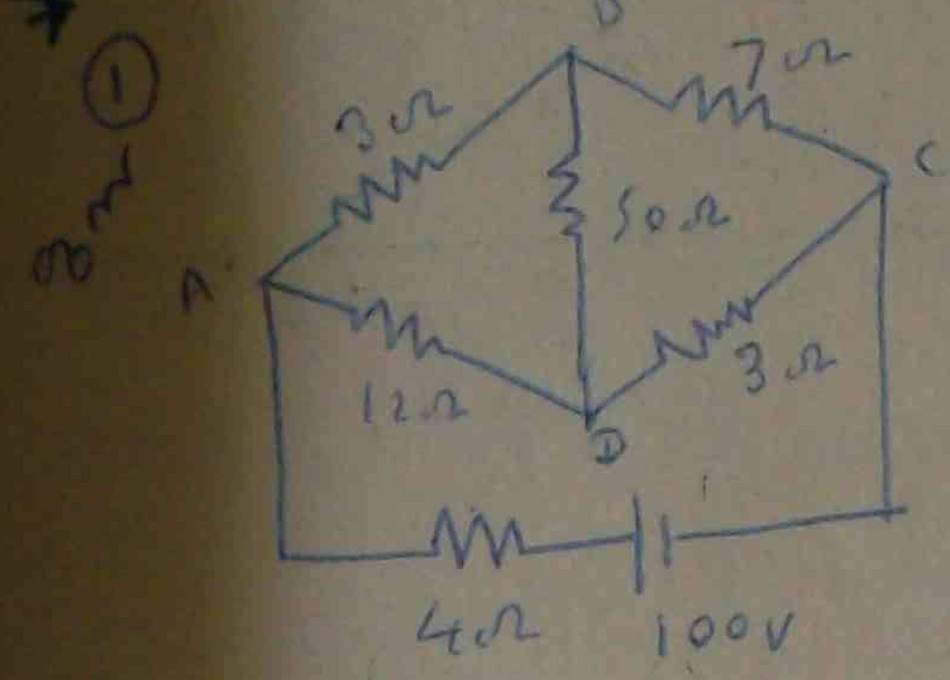
KN 75-

E. TECH

Maung Kyaw Naing 3EP3

P.G.T.I

①



50Ω Resistance ကိုဖြတ်စီးသော current ကို Thevenin's theorem ဖြင့်ရှာပါ။

BD ကိုဖြုတ်ပါ။

$$Z_T = \frac{10 \times 15}{10+15} + 4$$

$$= \frac{150}{25} + 4 = 10\Omega$$

$$I_t = \frac{100}{10} = 10 \text{ amp}$$

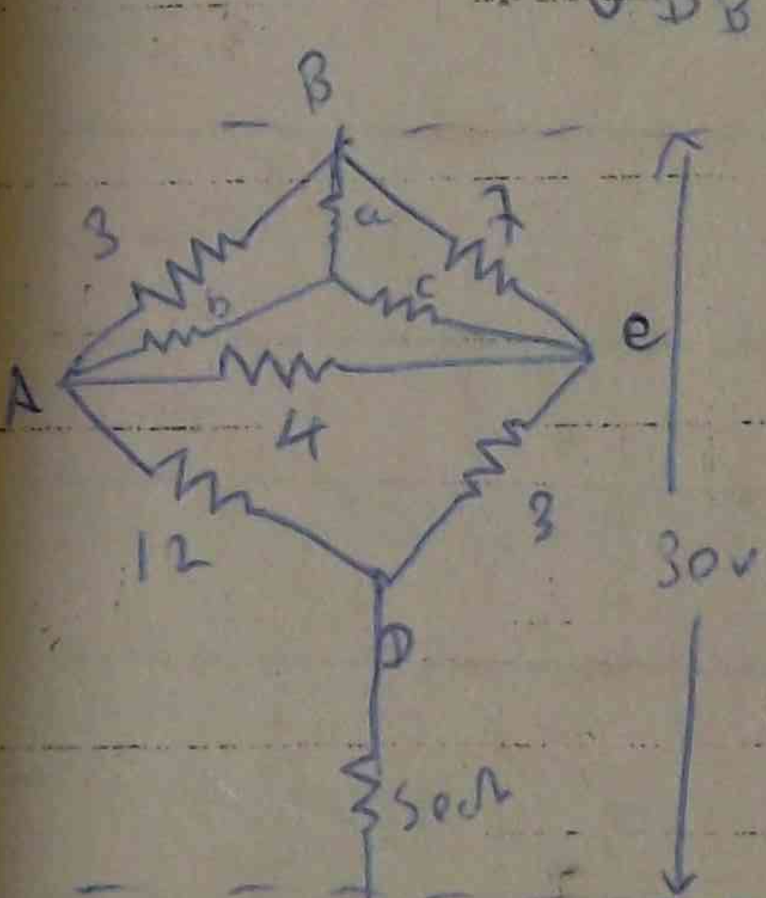
$$I_{ABC} = 10 \times \frac{15}{25} = 6 \text{ amp}$$

$$\therefore V_{AB} = 6 \times 3 = 18 \text{ volts}$$

$$I_{ADC} = 10 \times \frac{10}{25} = 4 \text{ amp}$$

$$V_{AD} = 4 \times 12 = 48 \text{ volts}$$

$$\therefore V_{DB} = 48 - 18 = 30 \text{ volts}$$



$$a = \frac{3 \times 7}{14} = 1.5\Omega$$

$$b = \frac{3 \times 4}{14} = \frac{12}{14} = .857\Omega$$

$$c = \frac{7 \times 4}{14} = 2\Omega$$

$$Z_T = 50 + 1.5 + \frac{12.857 \times 5}{12.857 + 5}$$

$$= 51.5 + \frac{89.3}{17.857}$$

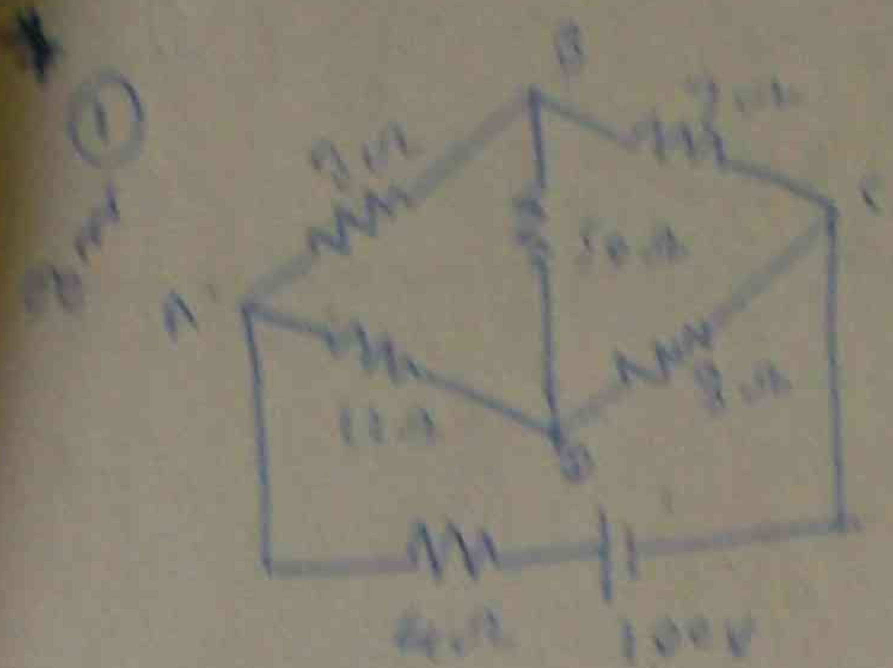
$$= 51.5 + 5$$

$$= 56.5\Omega$$

$$I_{DB} = \frac{30}{56.5} = .532 \text{ amp} \uparrow$$

1977 (Final Exam)

(1) [illegible]



50Ω Resistance ကိုဖြတ်စီးသော current ကို Thevenin's theorem ဖြင့်ရှာပါ။

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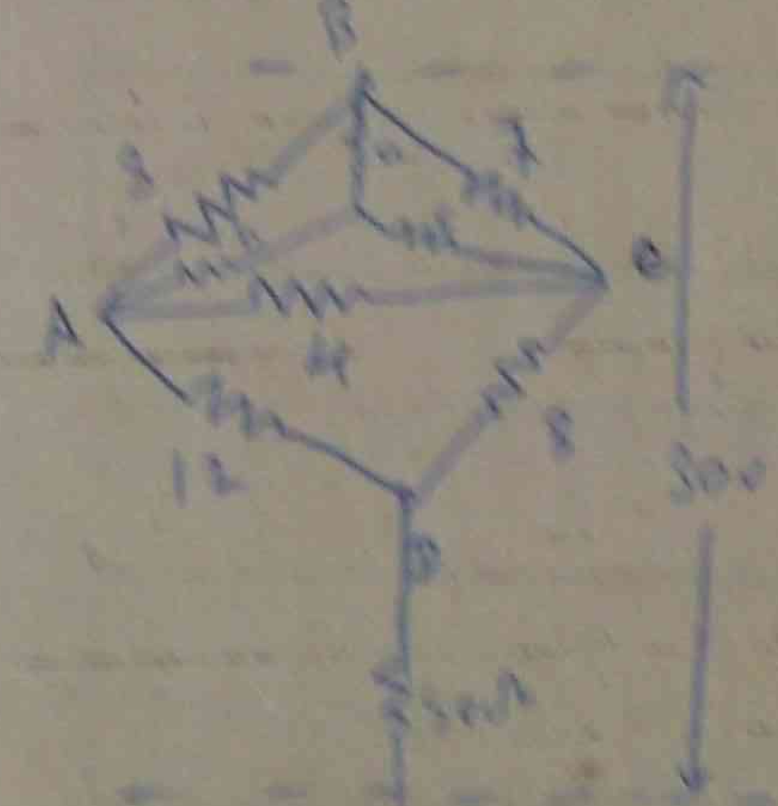
$V_{AD} = 4 \times 12 = 48$ volts

$V_{DB} = 48 - 18 = 30$ volts



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$b = \frac{3\times4}{14} = \frac{12}{14} = .857\Omega$

$c = \frac{7\times4}{14} = 2\Omega$

$Z_T = 50 + 1.5 + \frac{12.857\times8}{12.857+8}$

$= 51.5 + \frac{88.3}{17.857}$

$= 51.5 + 5$

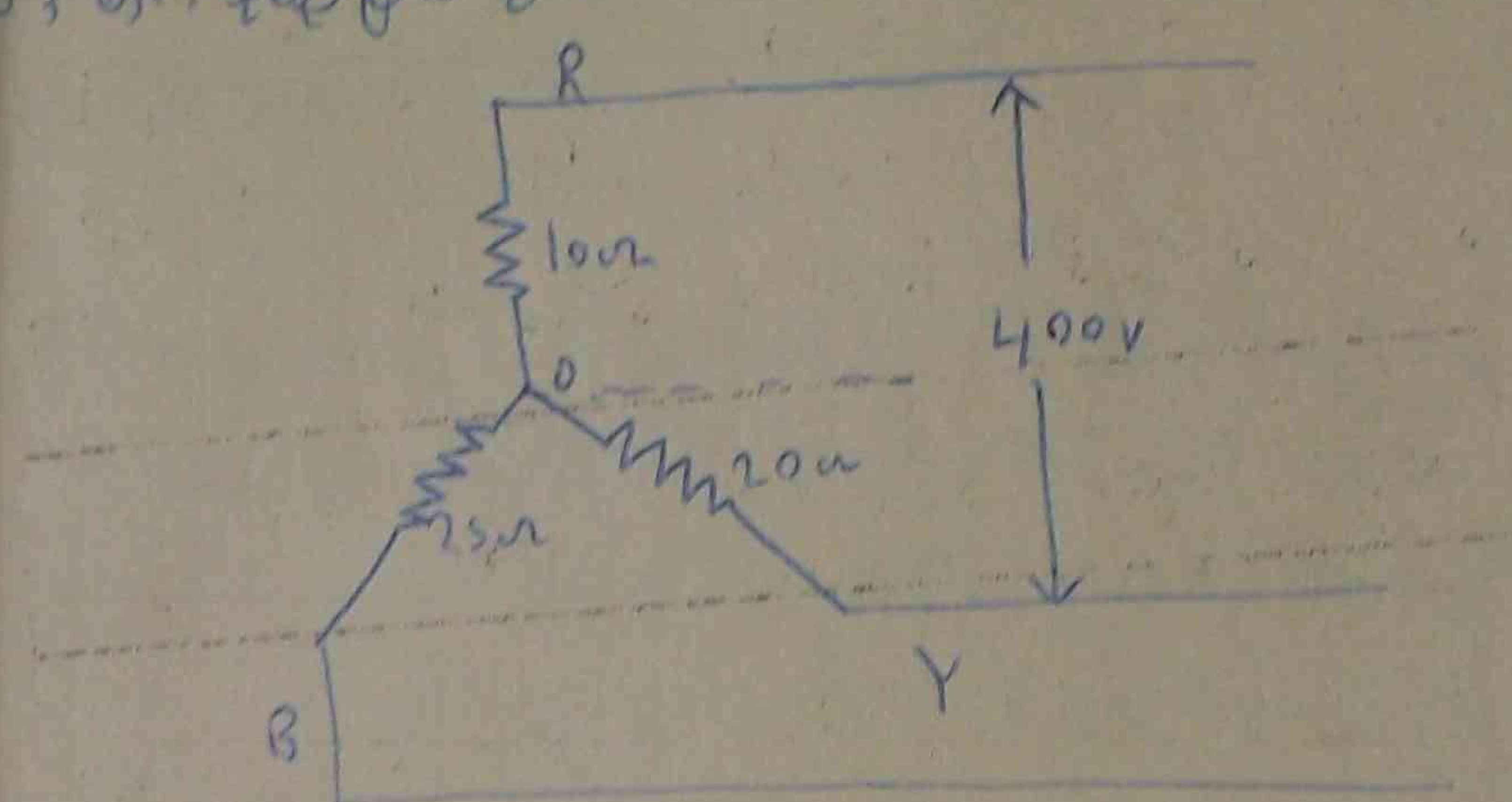
$= 56.5\Omega$

$I_{DB} = \frac{30}{56.5} = .532$ amp ↑

(၂) 3φ Balance load 4 wire တွင် ဘာကြောင့် Neutral current သည် သုည ဖြစ်သွားရသနည်း။

Non reactive resistor များ ဖြစ်ကြသော 10Ω, 20Ω နှင့် 25Ω တို့ကို star ချိတ်ထားပြီး R Y B phase တို့တွင် symmetrical 400 V ပေးထားသည်။ phase sequence RYB ဖြစ်လျှင် current, resistor တိုင်း၏ power နှင့် star point နှင့် Neutral ကြား၏ voltage တို့ကို ရှာပါ။

3φ Balance load 4 wire တွင် phase 3 ခုမှ စီးလာသော current တို့သည် neutral junction star point သို့ စီးဝင်ကြသည်နှင့် တပြိုင်နက် ... Neutral current သည် သုည ဖြစ်သွားရသည်။

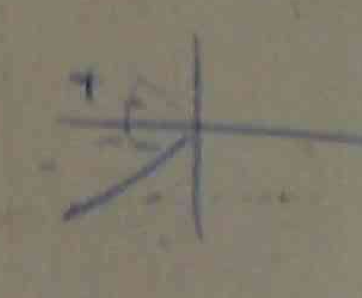


$$E_{phR} = \frac{400}{1.7321} = 231\ V$$

E_{phR} = Ref: vector ဖြစ်သည်။

$$E_N = \frac{E_{phR} Y_{R0} + E_{phY} Y_{Y0} + E_{phB} Y_{B0}}{Y_{R0} + Y_{Y0} + Y_{B0}}$$

$$= \frac{231\angle 0 \times \frac{1}{10} + 231\angle -120 \times \frac{1}{20} + 231\angle -240 \times \frac{1}{25}}{\frac{1}{10} + \frac{1}{20} + \frac{1}{25}}$$



$$= \frac{23.1\angle 0 + 11.55\angle -120 + 9.24\angle -240}{.1 + .05 + .04}$$

$$= \frac{23.1 + j0 + 11.55(-\cos 120 - j\sin 120) + 9.24(-\cos 240 + j\sin 240)}{.19}$$

$$= \frac{23.1 + j0 + 11.55(-\cos 60 - j\sin 60) + 9.24(-\cos 60 + j\sin 60)}{.19}$$

$$= \frac{23.1 + j0 - 5.78 - j10 - 4.62 + j8}{.19}$$

$$= \frac{12.7 - j2}{.19} = 66.8 - j10.52\ \text{Volts} = 67.7\angle -8.9$$

$$E_{R0} = E_{phR} - E_N$$
$$= 231\angle 0 - (66.8 - j10.52)$$
$$= 231 + j0 - 66.8 + j10.52$$
$$= 164.2 + j10.52$$
$$= 164.2 \angle 3.67 \text{ volts}$$

$$I_R = \frac{E_{R0}}{Z_{20}} = \frac{164.2 \angle 3.67}{10} = 16.42 \angle 3.67 \text{ amp}$$

$$\text{Power} = 16.42^2 \times 10 = 270 \times 10 = 2700 \text{ watts}$$

$$E_{Y0} = E_{phY} - E_N$$
$$= 231 \angle -120^\circ - 66.8 + j10.52$$
$$= 231 (-\cos 120^\circ - j\sin 120^\circ) - 66.8 + j10.52$$
$$= 231 (-\cos 60 - j\sin 60) - 66.8 + j10.52$$
$$= 231 (-.5 - j.866) - 66.8 + j10.52$$
$$= -115.5 - j200 - 66.8 + j10.52$$
$$= -182.3 - j189.48$$
$$= 263 \angle 180 + 46.1 \text{ volts}$$

$$I_Y = \frac{263 \angle 226.1}{20} = 13.15 \angle 226.1 \text{ amp}$$

$$\text{Power} = (13.15)^2 \times 20 = 173 \times 20 = 3460 \text{ watts}$$

$$E_{B0} = 231 \angle -240 - 66.8 + j10.52$$
$$= 231 (-\cos 240 + j\sin 240) - 66.8 + j10.52$$
$$= 231 (-\cos 60 + j\sin 60) - 66.8 + j10.52$$
$$= -115.5 + j200 - 66.8 + j10.52$$
$$= -182.3 + j210.52$$
$$= 279 \angle 180 - 49.1$$
$$= 279 \angle 130.9 \text{ volts}$$

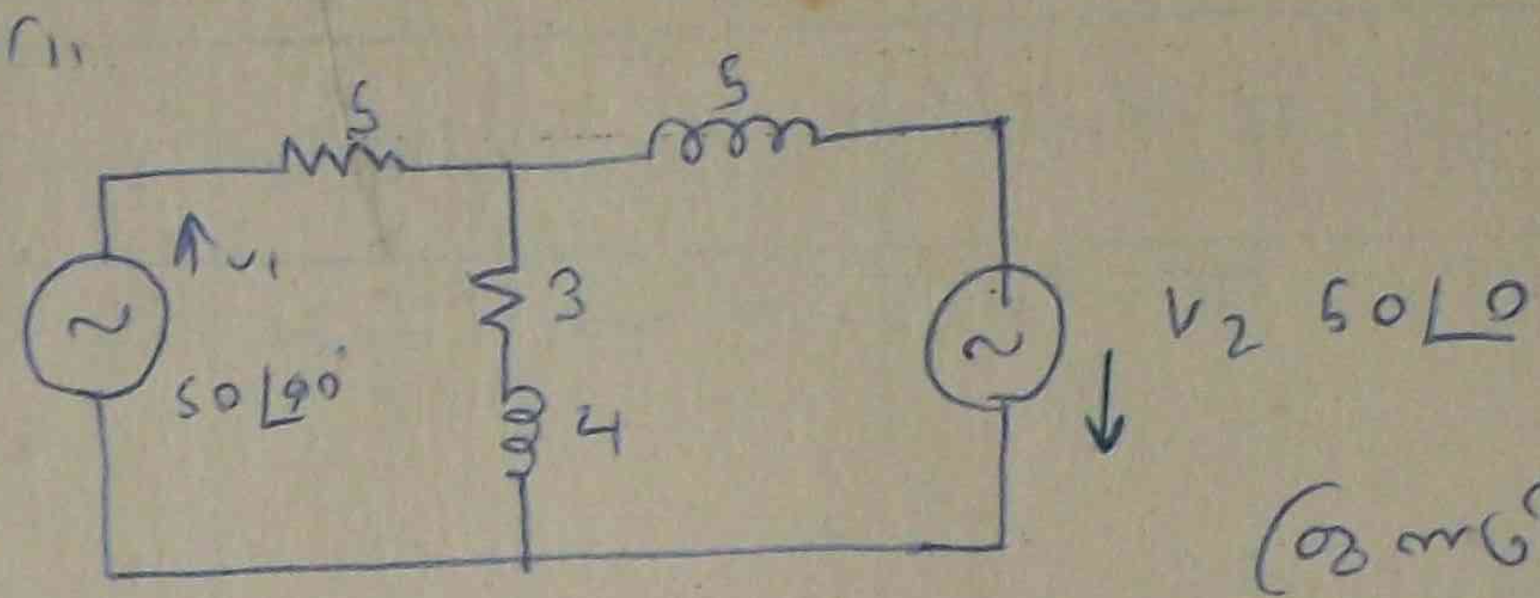
$$I_B = \frac{279}{25} \angle 130.9 = 11.15 \angle 130.9 \text{ amp}$$

$$\text{Power} = (11.15)^2 \times 25 = 124.5 \times 25$$
$$= 3110 \text{ watts}$$

(က) Super position theorem ကိုရှင်းလင်းဖော်ပြပါ။

(ခ) ပေးထားသော circuit ၌ 3 + J4 ရှိသည့်ဝင်ရိုး၌ current ကို super position theorem သုံး၍ရှာပါ။

supply source တစ်ခုထက်ပိုသော network များ၌ branch တစ်ခုခုတွင်စီးသော current ကို တစ်ကြိမ်လျှင် source တစ်ခုစီထား၍ ကျန် source များကို short ပြုလုပ်ပြီး ရရှိသော current များကို super position ပြုလုပ်ပေး ရသည်။



(အမှတ် ၁)

(4) lighting system အကြောင်းဖော်ပြပါ။

$40' \times 40'$ ရှိသော အခန်းတစ်ခုကို အခန်းမီးထွန်းမည်ဖြစ်သည်။ ... illumination သည် 10 lumen/sq ft ရရှိသော ... lumen ကိုရှာပါ။ mounting height 14 ft ဖြစ်ပါ။

(5) 1.5 tons ရှိသော motor car များသည် Disel Electric train တစ်စင်းသည် station ၂ခုကြား ... Time speed curve ... Station stop 20 sec ရှိသော schedule speed ကိုရှာပါ။

Power off t = brake applied

Time (sec)	11.5	23	29.3	41	58	124	140 -
Speed (mph)	12.5	25	30	35	39	32	0 -

6 (က) pf ကောင်းစေရန် ပြုလုပ်သည့် အကျိုးများ ပြဆိုင်းများ သုံးနိုင်သည်။

(ခ) 3φ 50Hz 3000V motor တစ်လုံး သည် 600HP ကို pf 0.75 lagging နှင့် effcy = .93 ရာခိုင်နှုန်းဖြင့် Delta ချိတ်ဆက် တပ်ဆင်ထားသည်။ တစ်ခုစီ capacitor unit များမှာ 600V စီခံနိုင်သော ... ... capacitor unit ငါးခု ရှိပြီး ပြုလုပ်ထားသော capacitor တစ်ခုစီ၏ capacitance ကိုရှာပါ။

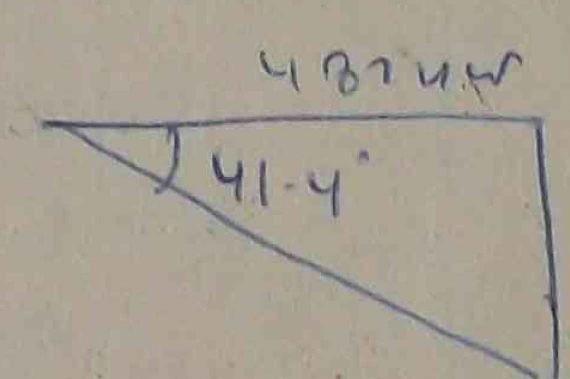
(က) pf ကောင်းစေရန် (1) static condenser (2) synchronous motor (3) phase advancing plant (4) capacitor တို့ သုံးနိုင်ပါသည်

(1) Static condenser များ တပ်ဆင်သည့် ... pf ကို မြင့်ပေးနိုင်ပါ။

(2) P synchronous motor များ ... pf ကို မြင့်ပေးနိုင် ... ... တို့ ... ... နိုင်ပါ။

(ခ)

$$\text{motor } I/p = \frac{600 \times .746}{.93} = \frac{448}{.93} = 482 \text{ kW}$$



$$kVAR = 482 \tan 41.4$$
$$= 482 \times .882$$
$$= 424 \, kVAR$$

$$E_{ph}^2 \, \omega C = \frac{kVAR \times 10^3}{3}$$

$$(3000)^2 \times 314 \times C = \frac{424 \times 10^3}{3}$$

$$9 \times 10^6 \times 314 \times C = \frac{424000}{3}$$

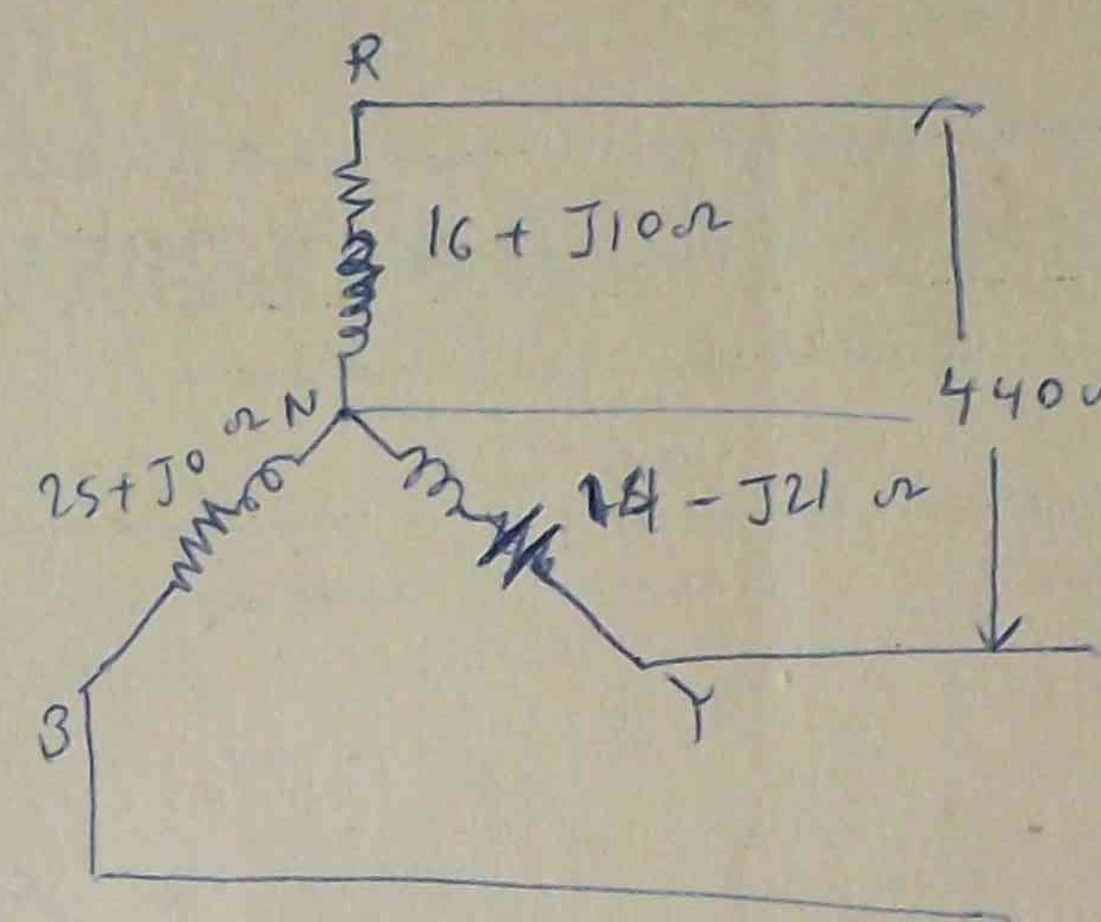
$$C = \frac{424000}{27 \times 314 \times 10^6}$$

$$= \frac{424000}{8480 \times 10^6} = 50 \, \mu F$$

$$C = 50 \times 5 = 250 \, \mu F$$

(7) 440V 3φ 4wire system ၌ ဆက်သွယ်ထားသော load တစ်ခုကို ဖော်ပြထားသည်။ ~~neutral~~ wire ပေါ်ရှိ load များ၏ total power နှင့် ~~current of~~ ကိုရှာ။

R နှင့် N ကြား တွင် (16 + J10)Ω Y နှင့် N ကြား တွင် (14 − J21)Ω B နှင့် N ကြား တွင် (25 + J0)Ω sequence R Y B



$$E_N = \frac{E_{RPN} Y_{RN} + E_{YPN} Y_{YN} + E_{BPN} Y_{BN}}{\dot{Y}_{RN} + \dot{Y}_{YN} + \dot{Y}_{BN}}$$

$$= \frac{254\angle 0 \times \frac{1}{16+J10} + 254\angle{-120} \times \frac{1}{14-J21} + 254\angle{-240} \times \frac{1}{25+J0}}{\frac{1}{16+J10} + \frac{1}{14-J21} + \frac{1}{25+J0}}$$

$$= \frac{254\angle 0 \times \frac{1}{18.85\angle 32} + 254\angle{-120} \times \frac{1}{25.2\angle{-56.3}} + \frac{254\angle{-240}}{25\angle 0}}{\frac{1}{18.85\angle 32} + \frac{1}{25.2\angle{-56.3}} + \frac{1}{25\angle 0}}$$

$$= \frac{13.48\angle{-32} + 10.08\angle{-63.7} + 10.15\angle{-240}}{.053\angle{-32} + .0397\angle 56.3 + .04\angle 0}$$

$$= \frac{13.48\cos 32 - J13.48\sin 32 + 10.08\cos 63.7 - J10.08\sin 63.7 + 10.15(-\cos 240 + J\sin 240)}{.053\cos 32 - J.053\sin 32 + .0397\cos 56.3 + J.0397\sin 56.3 + .04}$$

$$13.48 \times .848 - J13.48 \times .53 + 10.08 \times .443 - J10.08 \times .896$$

$$- 10.15 \times .5 + J10.15 \times .866$$

$$= \overline{.053 \times .848 - J.053 \times .53 + .0397 \times .556 + J.0397 \times .832 + .04}$$

$$= \frac{11.42 - J7.15 + 4.47 - J9.05 - 5.075 + J8.8}{.045 - J.0281 + .02205 + J.033 + .04}$$

$$E_N = \frac{10.815 - J7.4}{.10705 + J.0049} = \frac{13.08 \angle -34.4}{.10705 \angle 2.62} = 122 \angle -37.02 \text{ volts}$$

$$E_N = 122(\cos 37.02 - J\sin 37.02)$$

$$= 97.4 - J73.5 \text{ volts}$$

$$E_{RN} = E_{phR} - E_N$$

$$= 254\angle 0 - (97.4 - J73.5)$$

$$= 254 + J0 - 97.4 + J73.5$$

$$= 156.6 + J73.5 = 173 \angle 25.15 \text{ volts}$$

$$\therefore I_R = \frac{173 \angle 25.15}{18.85 \angle 32} = 9.18 \angle -6.85 \text{ amp}$$

~~Power~~ $= E_{YN} = E_{phY} - E_N$

$$= 254\angle -120 - (97.4 - J73.5)$$

$$= 254(-\cos 120 - J\sin 120) - 97.4 + J73.5$$

$$= -127 - J220 - 97.4 + J73.5$$

$$= -224.4 - J146.5$$

$$= 268.5 \angle 180 + 33.15 \text{ volts}$$

$$I_Y = \frac{268.5 \angle 213.15}{25.2 \angle -36.3} = 10.65 \angle 269.45 \text{ amp}$$

$$E_{BN} = E_{pnB} - E_N$$

$$I_B:\quad E_{BN} = 254\,\angle{-240} - 97.4 + J\,73.5$$

$$= 254\left(-\cos 60 + J\sin 60\right) - 97.4 + J\,73.5$$

$$= -127 + J\,220 - 97.4 + J\,73.5$$

$$= -224.4 + J\,293.5$$

$$= 369\,\angle 180 + 37.4$$

$$= 369\,\angle 217.4 \text{ volts}$$

$$I_B = \frac{369\,\angle 217.4}{25\,\angle 0} = 14.68\,\angle 217.4 \text{ amp}$$

$$\text{Total power} = I_R^2 R_{RN} + I_Y^2 R_{YN} + I_B^2 R_{BN}$$

$$= (9.18)^2 \times 16 + (10.65)^2 \times 14 + (14.68)^2 \times 25$$

$$= 84.4 \times 16 + 113.5 \times 14 + 215.5 \times 25$$

$$= 1350 + 1590 + 5390 =$$

$$= 8330 \text{ watts}$$

$$I_N = \hat{I}_R + \hat{I}_Y + \hat{I}_B$$

$$= 9.18\,\angle{-6.85} + 10.65\,\angle 269.45 + 14.68\,\angle 217.4$$

$$= 9.18\cos 6.85 - J\,9.18\sin 6.85 + 0 - J\,10.65 - 14.68\cos 37.4 - J\,14.68\sin 37.4$$

$$= 9.18 \times .995 - J\,9.18 \times .1192 - J\,10.65 - 11.67 - J\,8.92$$

$$= 9.14 - J\,1.095 - J\,10.65 - 11.67 - J\,8.92$$

$$= -2.53 - J\,20.665$$

$$= 20.8\,\angle 180 + 83.02$$

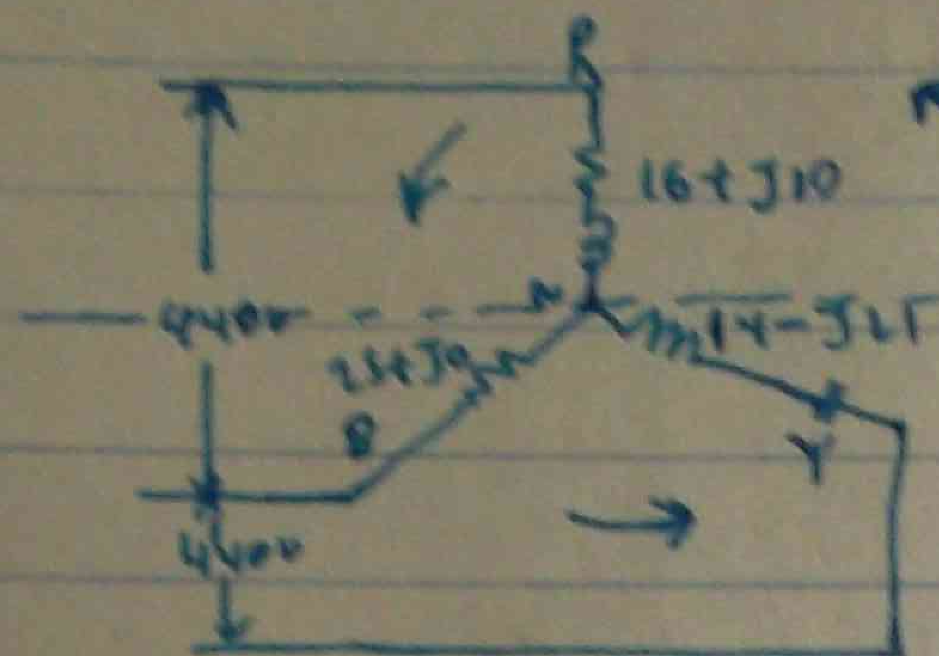
$$\text{Neutral current} = 20.8\,\angle 263.02 \text{ amp}$$

1979 no(5)

1973 no(5) 440V 3 ϕ 4 wire system [illegible] load [illegible]
load [illegible] Total Power [illegible]

R [illegible] N [illegible] $16 + J10\Omega$, Y [illegible] N [illegible] $14 - J21\Omega$ B [illegible] N [illegible] $25 + J0\Omega$

Sequence RYB



$E_{RN} = 254 \angle 90^\circ$ volts

$E_{YN} = 254 \angle -30^\circ$ volts

$E_{BN} = 254 \angle -150^\circ$ volts

$$I_{RN} = \frac{254 \angle 90}{16 + J10} = \frac{254 \angle 90^\circ}{18.85 \angle 32} = 13.48 \angle 58 \text{ amp}$$

$$I_{RN} = 13.48(\cos 58 + J\sin 58) = 13.48(.53 + J.848) = 7.15 + J11.45 \text{ amp}$$

$$I_{YN} = \frac{254 \angle -30^\circ}{14 - J21} = \frac{254 \angle -30^\circ}{25.2 \angle -56.3} = 10.08 \angle 26.3^\circ \text{ amp}$$

$$I_{YN} = 10.08(\cos 26.3 + J\sin 26.3)$$

$$= 10.08(.897 + J.4435) = 9.05 + J4.47 \text{ amp}$$

$$I_{BN} = \frac{254 \angle -150^\circ}{25} = 10.15 \angle -150^\circ$$

$$I_{BN} = 10.15(-.866 - J.5)$$

$$= -8.82 - J5.075 \text{ amp}$$

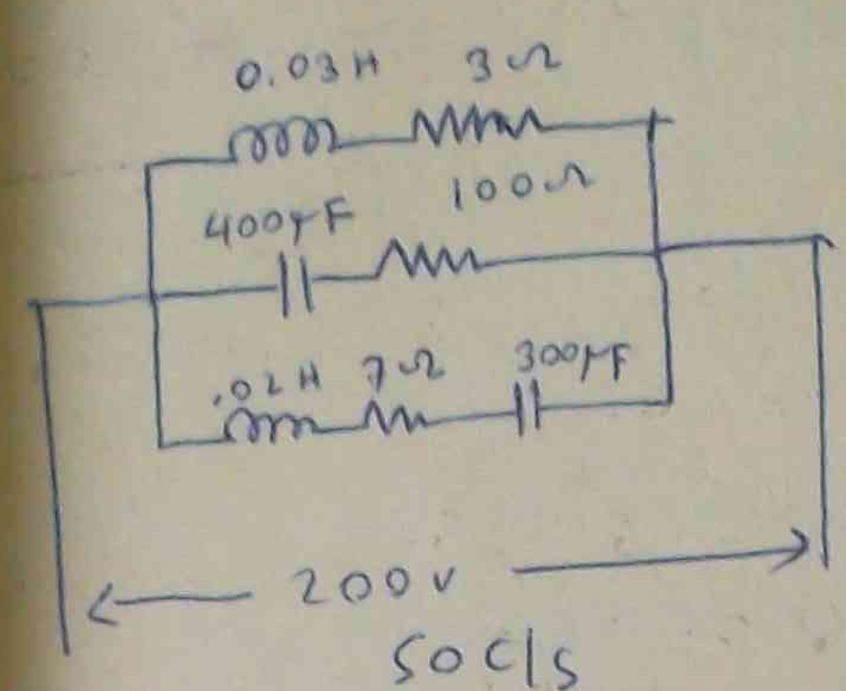
I_{N}. Total Power $= (13.48)^2 \times 16 + (10.08)^2 \times 14 + (10.15)^2 \times 25$

$= 181.8 \times 16 + 101.8 \times 14 + 103 \times 25$

$= 2910 + 1428 + 2575 = 6913$ watts

အောက်ပါတို့ကို ဖြင့်ပုံကြမ်းဖြင့် ဖြေဆိုပါ။ ကြောင်ပေါ် ၃ပြစ်များ:
(က) Pt ဒုံးကျင်း ၁ဖြင့် ပြခြင်း ... coefficient of adhesion
(ခ) ဓါတ်ရထား တား နှင့် ဆိုင်သော ... ဂဏန်းများ:
speed ၃ မျိုး မျိုး Period ၃ မျိုး မျိုး ကို
အကျဉ်း ရေးပြပါ။

(1977 Final Exam)

① 

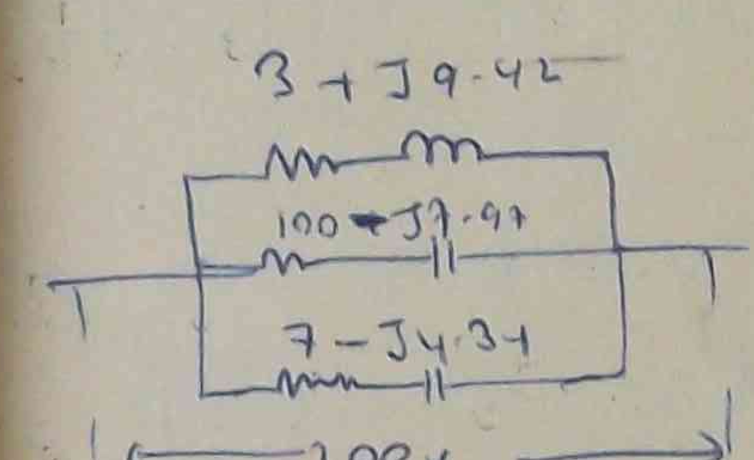
ပေးထားသော Circuit တွင် (က) Branch တခုစီမှ current (ခ) စုစုပေါင်း current တို့ကို admittance နည်းဖြင့် တွက်ပါ။

$.03H \quad X_L = 2\pi f L = 314 \times .03 = 9.42\,\Omega$

$400\mu F \quad X_C = \dfrac{1}{2\pi f C} = \dfrac{1000{,}000}{314 \times 400} = \dfrac{100{,}00}{1256} = 7.97$

$.02H \quad X_L = 314 \times .02 = \underline{\underline{6.28}}\,\Omega$

$300\mu F \quad X_C = \dfrac{1000{,}000}{314 \times 300} = \dfrac{1000{,}0}{942} = \underline{\underline{10.62\,\Omega}}$



$$Y_1 = \frac{3}{3^2+9.42^2} - J\frac{9.42}{3^2+9.42^2}$$

$$= \frac{3}{9+88.6} - J\frac{9.42}{9+88.6}$$

$$Y_1 = \frac{3}{97.6} - J\frac{9.42}{97.6}$$

$$= .0307 - J\,.0965$$

$$= .1013 \underline{\left| -72.35 \right.}\ \mho$$

$$Y_2 = \frac{100}{100^2+7.97^2} + J\frac{7.97}{100^2+7.97^2}$$

$$= \frac{100}{10063.5} + J\frac{7.97}{10063.5}$$

$$= .00994 + J\,.00793$$

$$= .01272 \underline{\left| 38.6 \right.}\ \mho$$

$$Y_3 = \frac{7}{7^2+4.34^2} + J\frac{4.34}{7^2+4.34^2}$$

$$= \frac{7}{49+18.85} + J\frac{4.34}{49+18.85}$$

$$= \frac{7}{67.85} + J\frac{4.34}{67.85}$$

$$= .1032 + J.064$$

$$= .121 \angle 31.8 \; \mho$$

$$Y_t = Y_1 + Y_2 + Y_3$$

$$= .0307 - J.0965 + .00994 + J.00793$$

$$+ .1032 + J.064$$

$$= .14384 - J.02457$$

$$= .146 \angle -9.7 \; \mho$$

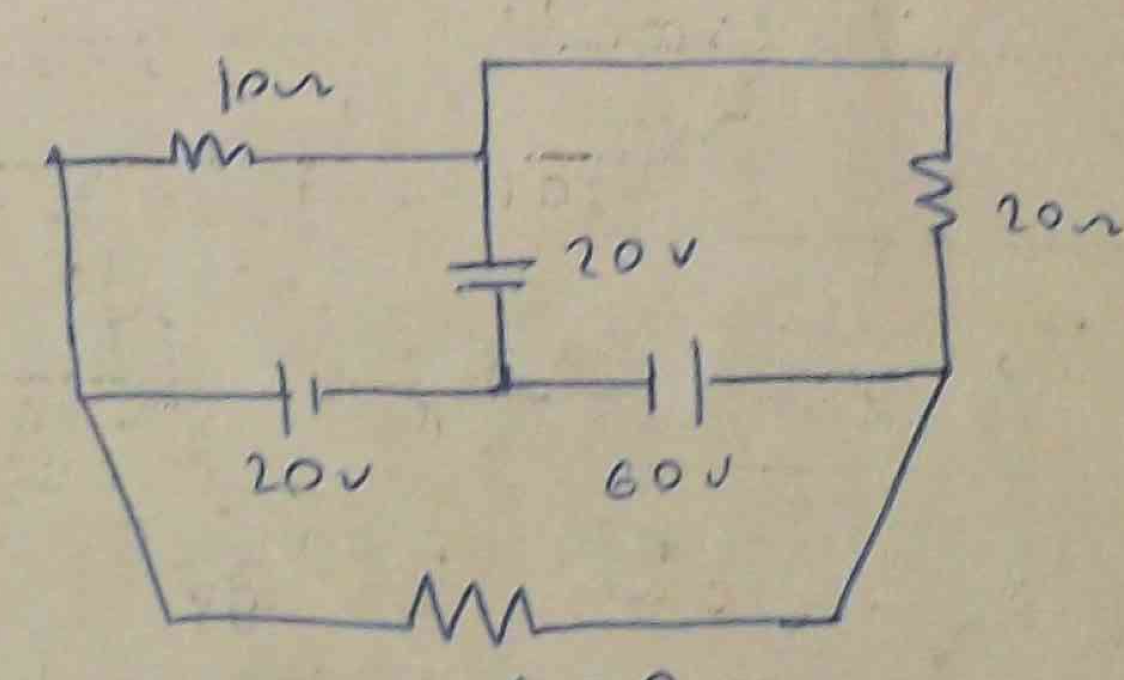
$$I_t = EY_t = .146 \times 200 = 29.2 \text{ amp}$$

$$I_1 = .1013 \times 200 = 20.26 \text{ amp}$$

$$I_2 = .01272 \times 200 = 2.544 \text{ amp}$$

$$I_3 = .121 \times 200 = 24.2 \text{ amp}$$

* ② super position theorem [illegible] battery [illegible] current [illegible]



(3) (က) [illegible] schedule speedနှင့် average speedကို [illegible]

(ခ) [illegible] 30 mph speed [illegible]

uniform accelaration နှင့် 24 sec [illegible]

Air resistance 13 lb/ton [illegible] sec [illegible]

coasting [illegible] 11 sec [illegible] 2 mph/sec

[illegible] braking [illegible] (က) Accelaration

(ခ) coasting ~~retan~~ rotation (ဂ) schedule speed ကို

[illegible] (station stopping period 20 sec)

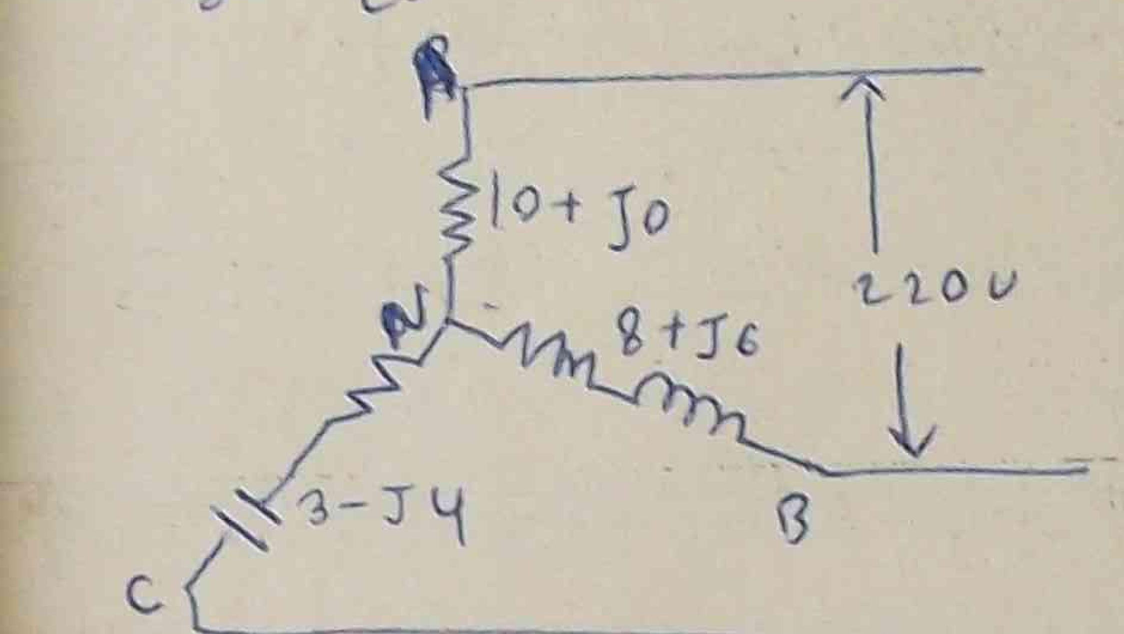
(4) [illegible] 3 wire system [illegible] load [illegible] star [illegible]

[illegible] $Z_A = 10 + J0\,\Omega$ $Z_B = 8 + J6\,\Omega$ $Z_C = 3 - J4\,\Omega$

supply voltage = 220 V frequency ABC [illegible] load

on star point နှင့် supply နှင့် neutral [illegible]

voltage [illegible]



$$E_N = \frac{E_{phA} \times Y_{AN} + E_{phB} Y_{BN} + E_{phC} Y_{CN}}{Y_{AN} + Y_{BN} + Y_{CN}}$$

$$= \frac{127\angle 0^\circ \times .1\angle 0 + 127\angle -120 \times \frac{1}{8+J6} + 127\angle -240 \times \frac{1}{3-J4}}{.1\angle 0 + \frac{1}{8+J6} + \frac{1}{3-J4}}$$

$$= \frac{12.7 + J0 + \frac{127\angle -120}{10\angle 36.8} + \frac{127\angle -240}{5\angle -53.2}}{.1 + J0 + \frac{1}{10\angle 36.8} + \frac{1}{5\angle -53.2}}$$

$$= \frac{12.7 + J0 + 12.7\angle{-156.8} + 25.4\angle{-186.8}}{.1 + J0 + .1\angle{-36.8} + .2\angle{53.2}}$$

$$= \frac{12.7 + J0 + 12.7(-\cos 23.2 - J\sin 23.2) + 25.4(-\cos 6.8 + J\sin 6.8)}{.1 + J0 + .1(\cos 36.8 - J36.8) + .2(\cos 53.2 + J\sin 53.2)}$$

$$= \frac{12.7 + J0 - 11.67 - J5 - 25.2 + J3.01}{.1 + J0 + .08 - J.06 + .12 + J.16}$$

$$= \frac{-24.17 - J1.99}{.3 + J.1}$$

$$E_N = \frac{24.17\angle{180+4.72}}{.3165\angle{18.42}} = 76.3\angle{166.3} \text{ volts}$$

$$E_N = 76.3(-\cos 13.7 + J\sin 13.7)$$

$$= 76.3(-.972 + J.237)$$

$$= -74 + J18.08 \text{ volts}$$

$$E_{AN} = E_{phA} - E_N$$

$$= 127\angle{0} - (-74 + J18.08)$$

$$= 127 + J0 + 74 - J18.08$$

$$= 201 - J18.08$$

$$= 201\angle{-5.65} \text{ volts}$$

$$I_A = \frac{201\angle{-5.65}}{10\angle{0}} = 20.1\angle{-5.65}$$

$$\hat{I}_A = 20.1\cos 5.65 - J\,20.1\sin 5.65$$

$$= 20.1 \times .995 - J20.1 \times .0985$$

$$= 20 - J1.98 \text{ amp}$$

$$\bar{E}_{BN} = E_{phB} - E_N$$

$$= 127 \angle -120^\circ + 74 - J18.08$$

$$= 127(-\cos 60 - J\sin 60) + 74 - J18.08$$

$$= -63.5 - J110 + 74 - J18.08$$

$$= 10.5 - J128.08$$

$$= 128.08 \angle -85.3 \text{ volts}$$

$$I_B = \frac{128.08 \angle -85.3}{10 \angle 36.8}$$

$$= 12.808 \angle -122.1 \text{ amp}$$

$$\hat{I}_B = 12.808(-\cos 57.9 - J\sin 57.9)$$

$$= -6.81 - J10.85 \text{ amp}$$

$$E_{CN} = E_{phC} - \bar{E}_N$$

$$= 127 \angle -240 + 74 - J18.08$$

$$= 127(-\cos 60 + J\sin 60) + 74 - J18.08$$

$$= -63.5 + J110 + 74 - J18.08$$

$$= 10.5 + J91.92$$

$$= 92.5 \angle 83.48 \text{ volts}$$

$$I_C = \frac{92.5 \angle 83.48}{5 \angle -53.2} = 18.5 \angle 136.68$$

$$\hat{I}_C = 18.5(-\cos 43.32 + J\sin 43.32)$$

$$= -13.48 + J12.67 \text{ amp}$$

$$\hat{I}_N = \hat{I}_A + \hat{I}_B + \hat{I}_C$$

$$= 20 - J1.98 + -6.81 - J10.85$$

$$-13.48 + J12.67$$

$$= -.29 - J.16$$

$$= .331 \angle 180 + 28 \ldots$$

Maung Kyaw Naing

3E.P (A)

စက်မှုလက်မှုသိပ္ပံ၊ မြင်းခြံမြို့။

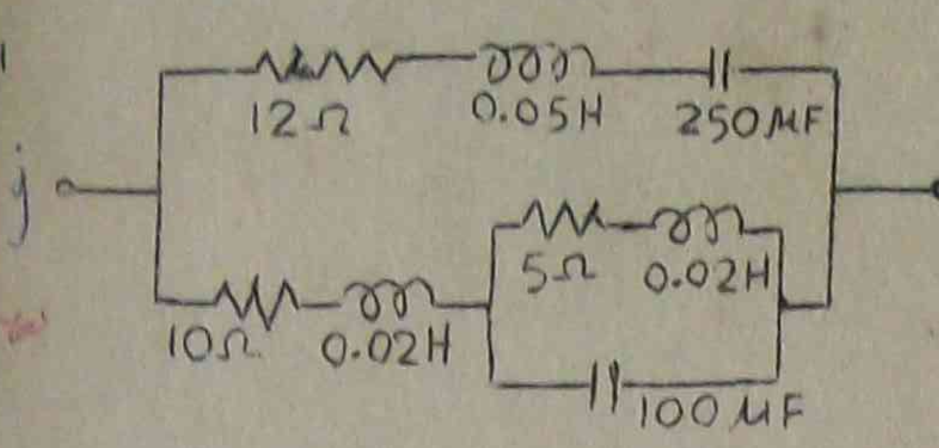
နှစ်ဝက်စာမေးပွဲ

တတိယနှစ် လျှပ်စစ်သင်တန်း — ၁၉၈၁ ခုနှစ် မတ်လ// ခွင့်ပြုချိန် ၃-နာရီ

ELECTRO-TECHNOLOGY ဘာသာရပ် — မေးခွန်းအားလုံး ဖြေဆိုပါ။

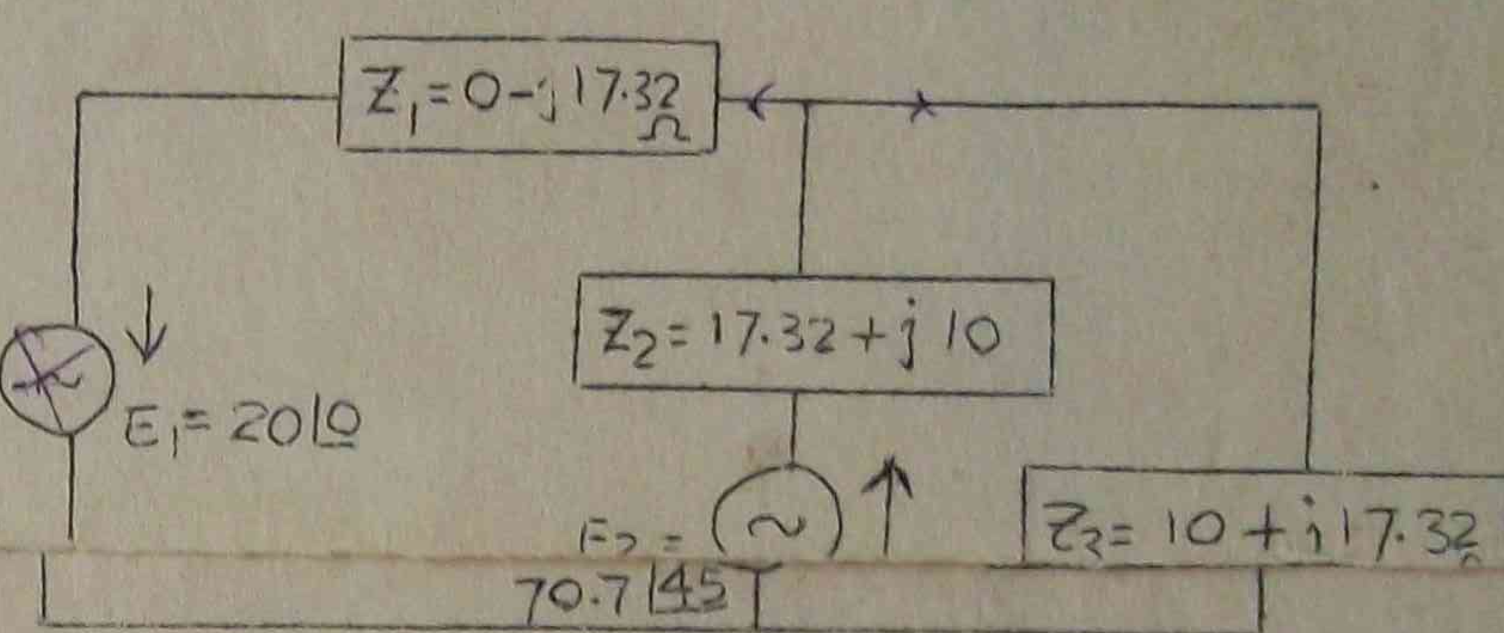
၁။ အောက်ပါ Impedance သုံးခုတို့ကို 200V, 50 Hz Supply နှင့် parallel ဆက်ထားသည်။ $Z_1 = 15-j20\,\Omega$; $Z_2 = 12+j16\,\Omega$, $Z_3 = 10+j0\,\Omega$; ckt ၏ စုစုပေါင်း admittance, Current, Power factor နှင့် အသုံးပြုသော Power တို့ကို ckt ပုံဆွဲ၍ admittance နည်းဖြင့် ရှာပါ။

၂။

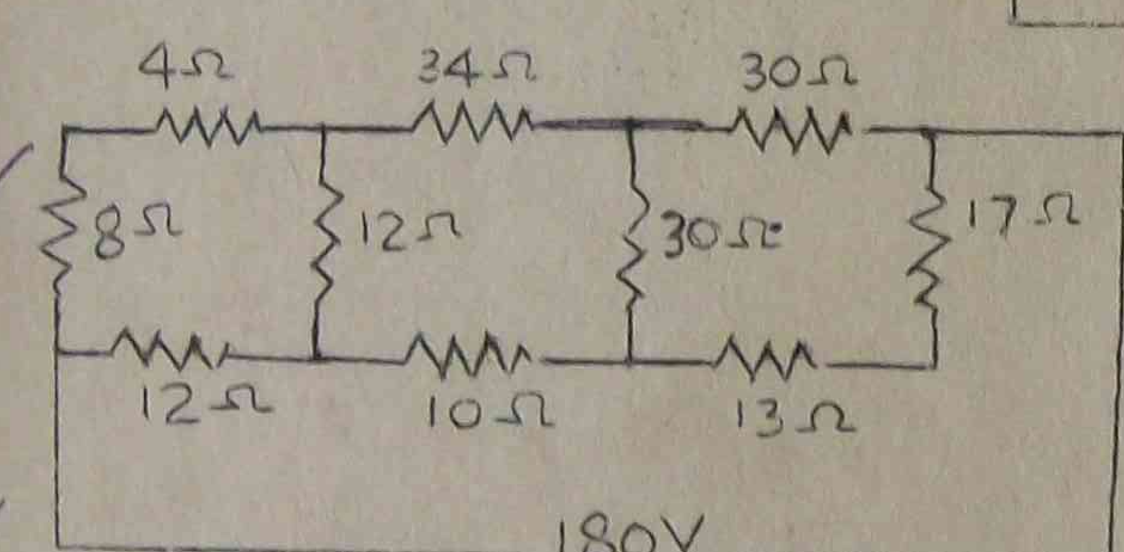


အောက်ပါ ckt ကို 100V, 50 c/s supply တွင် ဆက်ပေးသော် total admittance, total current နှင့် total P.f, 100 μF Cap: တွင် စီးမည့် current များကို ရှာပါ။

၃။ Superposition Theorem အရ branch အသီးသီးတွင် စီးမည့် ကရင့်များနှင့် လားရာတို့ကို ရှာပါ။



၄။



Thevenin's Theorem အရ 10Ω တွင် စီးမည့် ကရင့်ကို ရှာပါ။

၅။ အောက်ပါ Bridge သည် မည်သည့် Bridge မျိုး ဖြစ်သည်ကို ဖော်၍ circuit ပုံစံ ဆွဲပြပါ။
A.C Bridge ABCD တွင် အောက်ပါအတိုင်း Impedance များ ရှိနေ၏။ လက်တံ AB တွင် unknown coil နှင့် regulator 600Ω ဆက်လျက်ရှိ၏။ လက်တံ BC တွင် No Loss 1 μF condenser နှင့် 20Ω N.i resistor တို့ series ရှိသည်။ လက်တံ CD တွင် No Loss 0.5 μF condenser, လက်တံ DA တွင် Non-reactive resistor 2850Ω တို့ရှိ၏ 50 c/s a.c voltage တခုကို BD ကိုခွ၍ ဆက်ထားသော Detector zero ပြလျှင် unknown coil ၏ resist: နှင့် Inductance တို့ကို ရှာပါ။ impedance တန်ဖိုးလည်း တွက်ပြပါ။

၆။ 3000V, 50 c/s, 3Φ, 375 H.P Induction မော်တာတလုံး၏ P.F မှာ 0.75 Lag: နှင့် Efficiency 92% ဖြစ်သည်။ Total P.f ကို 0.9 Lag: သို့ တိုးမြှင့်ရန် Star connected condenser bank ကို အသုံးပြုသည်။ condenser bank ၏ phase တခုစီ၌ capacitor သုံးခုကို series ဆက်ထားပါက ၎င်း capacitor တလုံး၏ capacitance ကို တွက်ပါ။

neutral point [illegible] load $= .331 \times 76.3 \cos(208.9 - 166.3)$

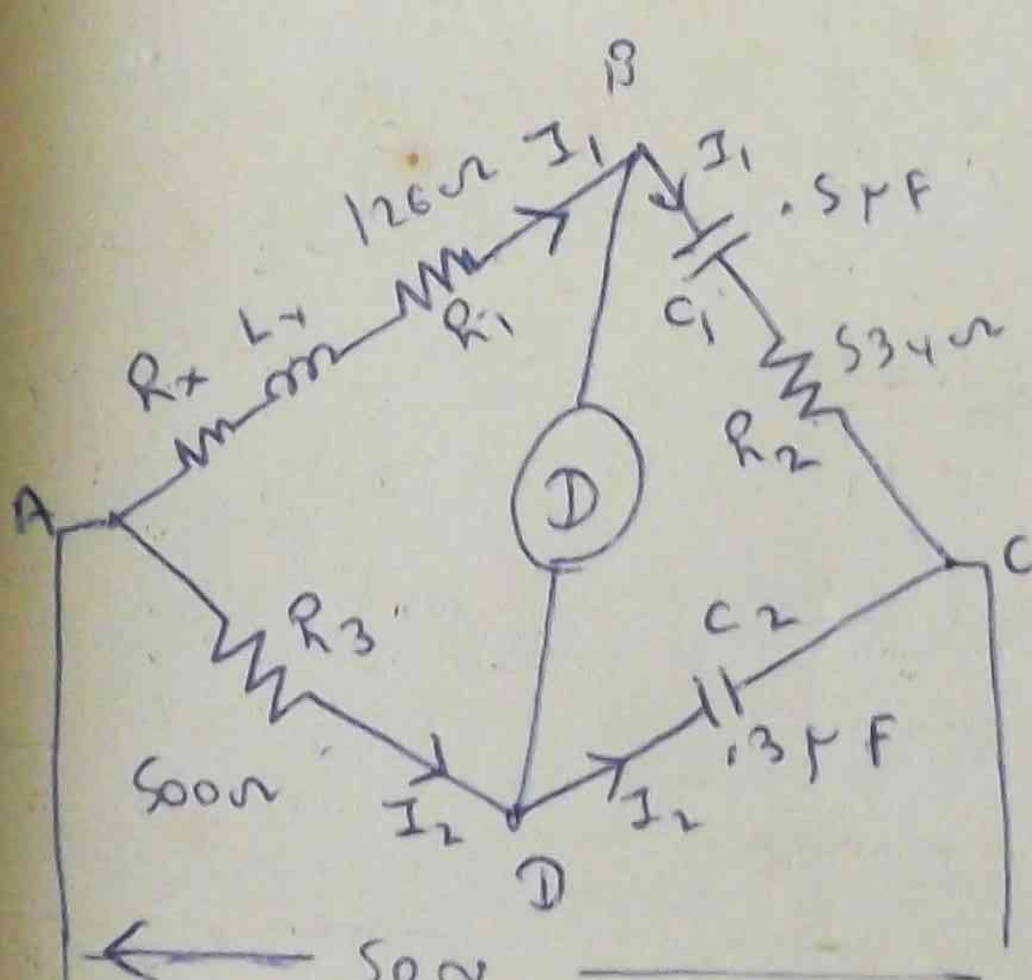
$= .331 \times 76.3 \cos(208.9 - 166.3)$

$= 25.25 \cos 42.6$

$= 25.25 \times .736$

$= 18.6$ watts

* (5) AC Bridge [illegible] AB [illegible] unknown impedance coil [illegible] 126Ω [illegible] series [illegible] BC [illegible] 0.5μF capacitor [illegible] 534Ω series [illegible] CD [illegible] loss free 0.3μF capacitor [illegible] DA [illegible] 500Ω [illegible] AC [illegible] 50 ~ AC voltage [illegible] BD [illegible] detector [illegible] balance [illegible] coil [illegible] resistance [illegible] inductance [illegible] bridge [illegible]



$Z_{AB} = (R_1 + R_x) + j\omega L_x \qquad Z_{BC} = R_2 + \frac{1}{j\omega C_1}$

$Z_{AD} = R_3 \qquad Z_{BC} = \frac{1 + j\omega C_1 R_2}{j\omega C_1}$

$Z_{CD} = \frac{1}{j\omega C_2}$

$I_1 \left[(R_1 + R_x) + j\omega L_x \right] = I_2 R_3$ —— (1)

$I_1 \left[\frac{1 + j\omega C_1 R_2}{j\omega C_1} \right] = I_2 \times \frac{1}{j\omega C_2}$ —— (2)

(1) ÷ (2) → $\frac{j\omega C_1 \left[(R_1 + R_x) + j\omega L_x \right]}{1 + j\omega C_1 R_2} = j\omega C_2 R_3$

$$\frac{j\omega C_1R_1 + j\omega C_1R_x - \omega^2 C_1L_x}{1 + j\omega C_1R_2} = j\omega C_2R_3$$

$$j\omega C_1R_1 + j\omega C_1R_x - \omega^2 C_1L_x = -\omega^2 C_1C_2R_2R_3 + j\omega C_2R_3$$

Real နှင့် imag: term များ ကို equate လုပ်သော် -

$$C_1R_1 + C_1R_x = C_2R_3$$

$$C_1R_x = C_2R_3 - C_1R_1$$

$$R_x = \frac{C_2R_3 - C_1R_1}{C_1}$$

$$= \frac{.3 \times 500 - .5 \times 126}{.5}$$

$$= \frac{150 - 63}{.5} = \frac{87}{.5} = 174\,\Omega$$

$$C_1L_x = C_1C_2R_2R_3$$

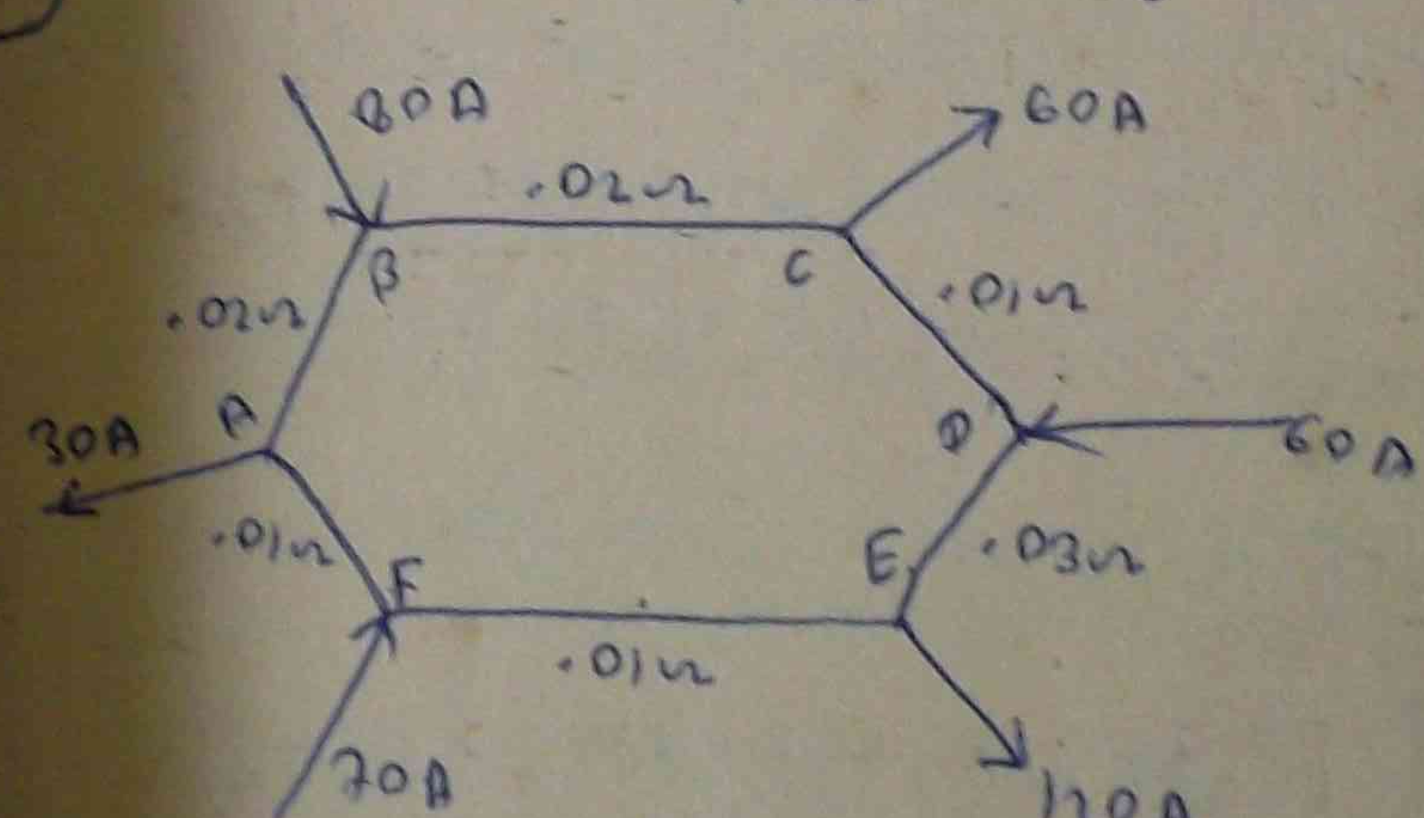
$$L_x = C_2R_2R_3$$

$$= .3 \times 10^{-6} \times 534 \times 500$$

$$= 150 \times 534 \times 10^{-6}$$

$$= .08 \text{ Henary}$$

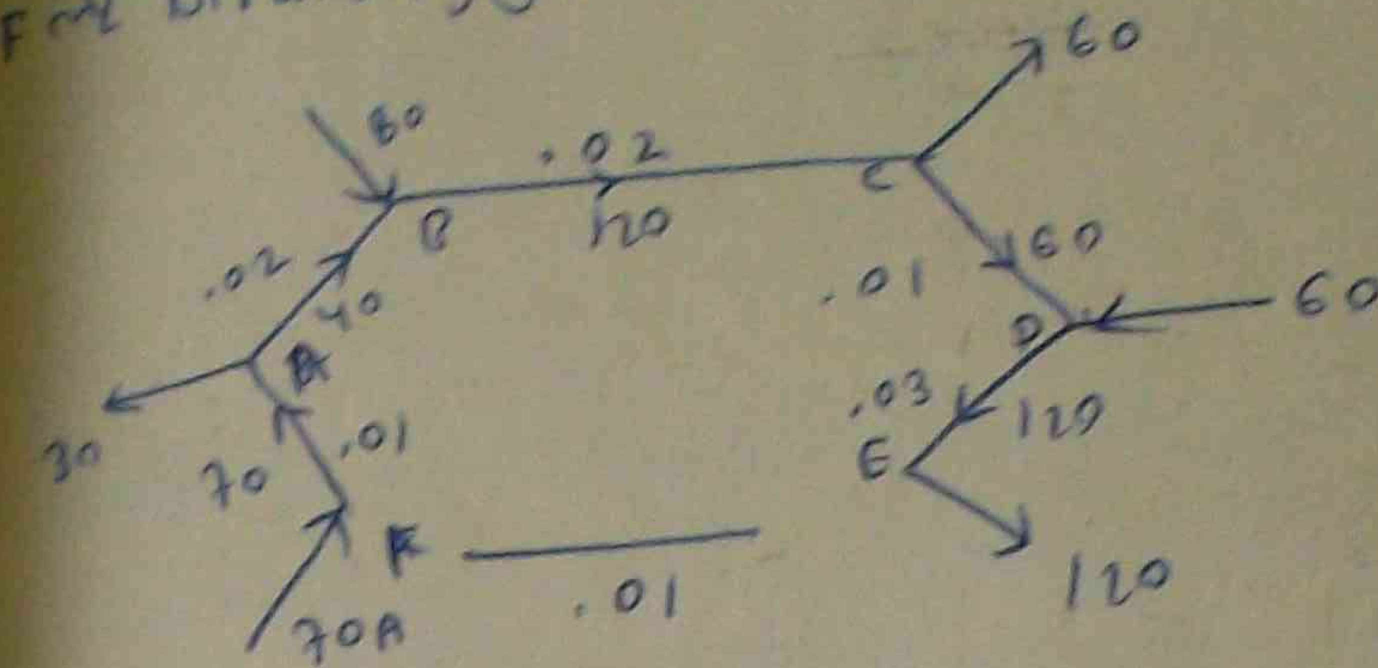
* (6) Thevenin's theorem ကို ဖော်ပြပါ။



Thevenin's theorem ကို သုံး၍ branch တိုင်း တွင် စီးသော current ကို ရှာပါ။

Network ရှိ branch တစ်ခု၌ စီးသော current ကို ရှာလိုလျှင် branch ကို network မှ ဖြတ်ထုတ်ပြီး resistance နှင့် နှင့် ဖြတ်ထား၍ ကျန်ရှိသော network resistance ကို ရှာ ပြီး နှင့် ဖြတ်ထား၍ ကျန်ရှိသော voltage ကို ရှာ ပါ။

EF ရှိ branching ပြလျှင်



$ZT = .01 + .01 + .02 + .02 + .01 + .03$

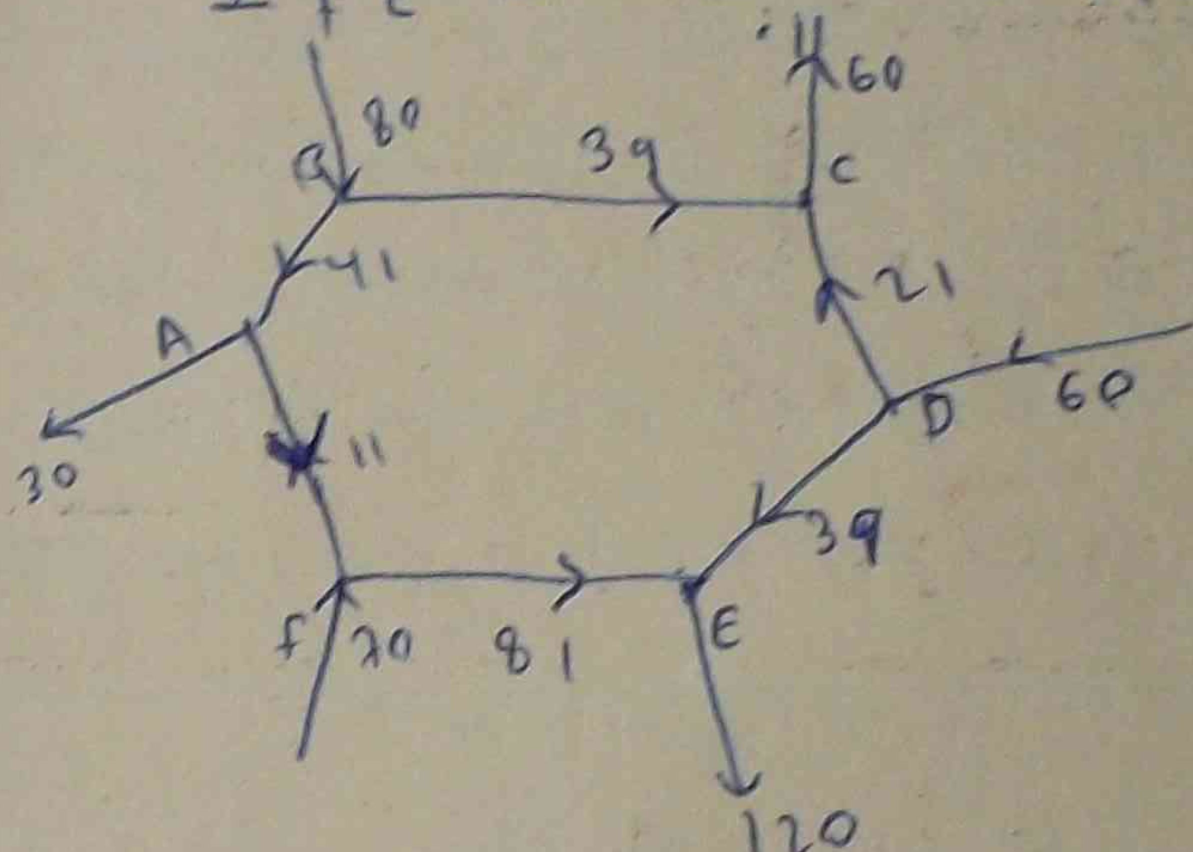
$= .1\,\Omega$

$V_{EF} = 70 \times .01 + .02 \times 40 + .02 \times 120 + .01 \times 60 + .03 \times 120$

$= .7 + .8 + 2.4 + .6 + 3.6$

$= 8.1$ volts

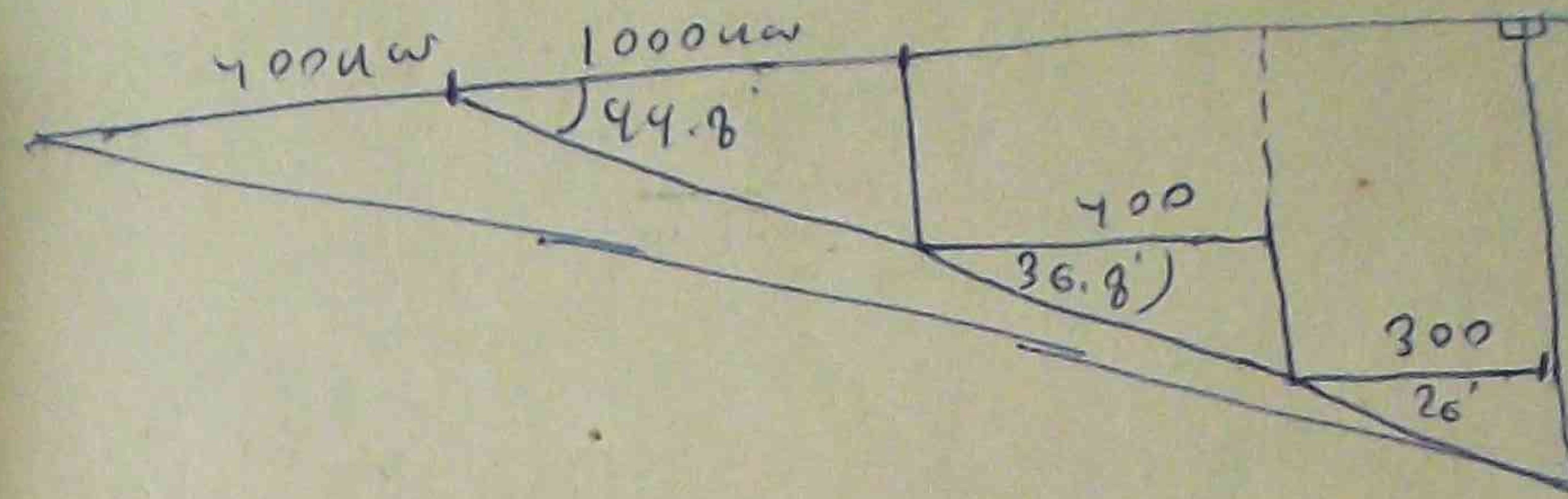
$I_{FE} = \dfrac{8.1}{.1} = 81$ amp



EF = 81 amp
BE = 39 amp
DC = 21 amp
BC = 39 amp
BA = 41 amp
AF = 11 amp

Ans

(7) 6600V star connected Alternator ၂လုံးကို အပြိုင်ဆောင်း၍ အောက်ပါ loadများကို supply ပေးထားပါ၏ 400kW unity pf, 1000kW ကို 0.71 pf lagging, 400kW ကို 0.8 pf lagging, 300kW ကို 0.9 pf lagging ဖြစ်ပါ၏ Alternator တစ်လုံး၏ output current မှာ 110 amp 0.9 pf lagging ဖြစ်သော် ကျန် Alternator တစ်လုံး၏ output current နှင့် Power factor ကို ရှာပါ။



$kW_T = 400 + 1000 + 400 + 300$

$= 2100 kW$

$kVAR_T = 1000 \tan 44.8 + 400 \tan 36.8 + 300 \tan 26$

$= 1000 \times .994 + 400 \times .748 + 300 \times .488$

$= 994 + 299 + 146.8$

$= 1439.8\ kVAR$

Alternator ရဲ့ Power $= \sqrt{3} E I \cos\theta$

$= \underline{1.7321 \times 6.6} \times 110 \times .9$

$= 11.43 \times 99$

$= 1132 kW$

$kVAR = 1132 \tan 26$

$= 1132 \times .488$

$= 554\ kVAR$

ကျန်ရဲ့ $kW = 2100 - 1132 = 968 kW$

" $kVAR = 1439.8 - 554 = 885.8\ kVAR$

$\tan\theta = \dfrac{885.8}{968} = .915$

$\theta = \tan^{-1} .915 = 42.4°$

$Pf = \cos\theta = \cos 42.4 = .738$ lagging

$\sqrt{3} E I \cos\theta = 968$

$1.731 \times 6.6 \times I \times .738 = 968$

$11.43 \times I \times .738 = 968$

$8.44 I = 968$

$I = 115$ amp

(8) (က) utiligation factor, mscp, luminous flux [illegible]

direct lighting [illegible] 100 ft [illegible] 16 ft

(ခ) 100 watts [illegible] 200 watts [illegible] offer [illegible]

[illegible]

2 candles per watt [illegible]

[illegible] illumination [illegible]

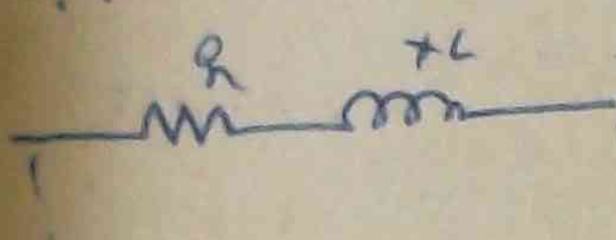
(1978) Final Exam

(1) Resistance [illegible] inductance [illegible] circuit [illegible] Total admittance [illegible] (.05 − J.08) mho [illegible] resistance

(က) series (ခ) parallel [illegible]

[illegible] inductive reactance [illegible]

series [illegible]



$$Y_t = .05 - J.08$$

$$Z_t = \frac{1}{.05 - J.08}\ \Omega$$

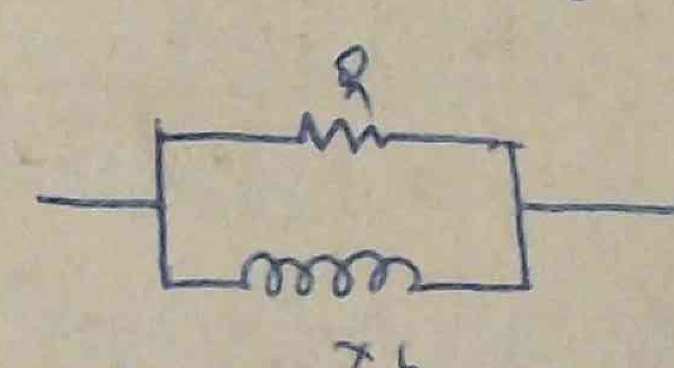
$$R + JX_L = \frac{1}{.0943\angle -58}$$

$$R + JX_L = 10.6\angle 58$$

$$R + JX_L = 10.6\cos 58 + J10.6\sin 58$$

$$\therefore R = 5.62\,\Omega \qquad X_L = 9\,\Omega$$

Parallel [illegible]



$$\frac{1}{R} + \frac{1}{JX_L} = .05 - J.08$$

$$\frac{1}{R} = .05 \qquad \therefore R = \frac{1}{.05} = 20\,\Omega$$

$$\frac{1}{JX_L} = -j.08 \qquad X_L = \frac{1}{.08} = 12.5\,\Omega$$

(2) Load 3 [illegible] parallel [illegible] circuit [illegible] admittance [illegible] 0.154 − J.008 mho [illegible] Load [illegible] admittance [illegible] 0.13 − J.04 mho [illegible] admittance, resistance, reactance, current [illegible] P F [illegible] Reactance [illegible] 200V 50Hz [illegible] branch [illegible] circuit [illegible] current [illegible] P F [illegible]

⑧ (က) utligation factor mscp, luminous flux [illegible]

direct lighting [illegible]

(ခ) 100watts [illegible] 200watts [illegible] 100ft [illegible] 16ft [illegible] 0 [illegible]

2 candles per watt [illegible]

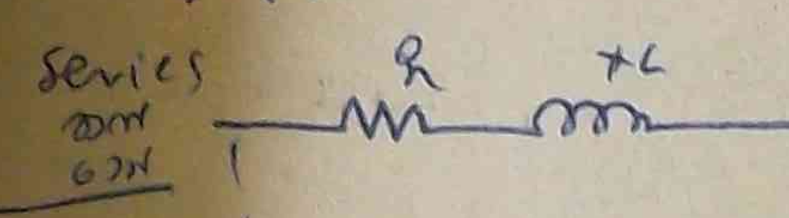
[illegible] illumination [illegible]

(1978) Final Exam

① Resistance [illegible] inductance [illegible] circuit [illegible] total admittance [illegible] (.05 − J.08) mho [illegible]

(က) series (ခ) parallel [illegible] resistance [illegible] inductive reactance [illegible]

series [illegible]



$$Y_t = .05 - J.08$$

$$Z_t = \frac{1}{.05 - J.08}\ \Omega$$

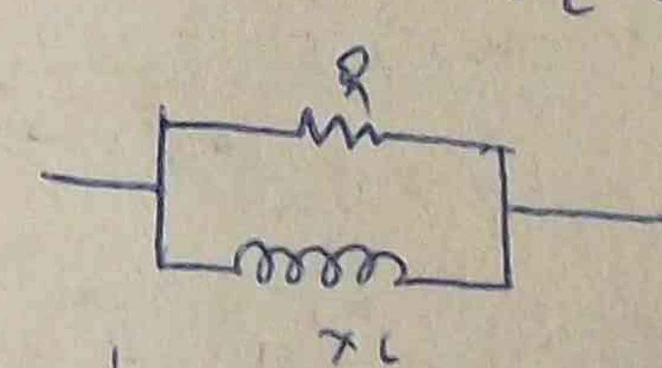
$$R + JX_L = \frac{1}{.0943\angle -58^\circ}$$

$$R + JX_L = 10.6\angle 58^\circ$$

$$R + JX_L = 10.6\cos 58 + J10.6\sin 58$$

$$\therefore R = 5.62\Omega \qquad X_L = 9\Omega$$

Parallel [illegible]



$$\frac{1}{R} + \frac{1}{JX_L} = .05 - J.08$$

$$\frac{1}{R} = .05 \qquad \therefore R = \frac{1}{.05} = 20\Omega$$

$$\frac{1}{JX_L} = -J.08 \qquad X_L = \frac{1}{.08} = 12.5\Omega$$

③ Load 3 [illegible] parallel [illegible] circuit [illegible] admittance [illegible] 0.154 − J.008 mho [illegible] load [illegible] admittance [illegible] 0.13 − J.04 mho [illegible] load [illegible] admittance, resistance, reactance, current [illegible] P.F [illegible] Reactance [illegible] supply [illegible] 200V 50Hz [illegible] branch [illegible] current [illegible] circuit [illegible] current [illegible] P.F [illegible]

ကျန် Load ဖိုင်ရဲ admittance $= 0.154 - J.008 - .13 + J.04$

$= .024 + J.032$

$= .04 \angle 53.1$ ~~℧~~ ℧

~~$Y=$~~ ~~$.04$~~ $Z_T = \dfrac{1}{.04 \angle 53.1}$

$= 25 \angle -53.1$

$Z = 25\cos 53.1 - J 25 \sin 53.1$

$= 15 - J20$

Resistance $= 15\Omega$ $\quad I = EY$

reactance $= 20\Omega$

PF $=$ .6 ~~lagg~~ in Leading
capacitive reactance

$Y_t = .154 - J.008$

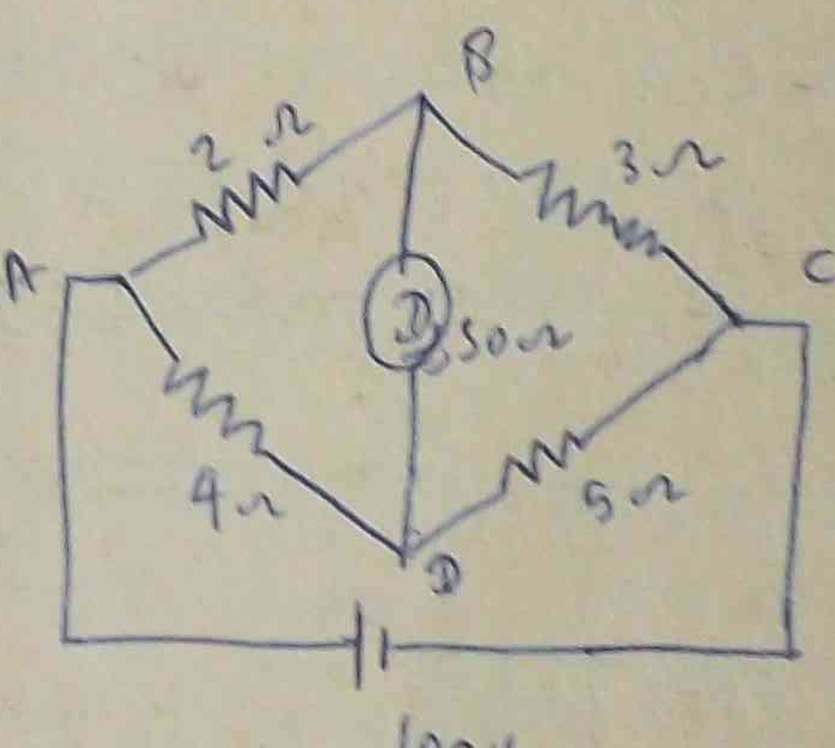
$= .154 \angle -2.98$

current $= 200 \times .154 \angle -2.98$

$= 30.8 \angle -2.98$

Pf $= \cos 2.98 = .998$ Lagging

(3)



Resistance 50Ω ရှိသော meter ထဲသို့ဖြတ်သော current ကို Thevenin's theorem ဖြင့်ရှာပါ။

BD ကိုဖြုတ်လျှင် $\quad I_{ABC} = \dfrac{100}{23}$ amp

$V_{AB} = \dfrac{100}{23} \times 2 = \dfrac{200}{23} = 8.7V$

$I_{ADC} = \dfrac{100}{20}$ amp

$V_{AD} = \dfrac{100}{20} \times 4 = 20V$

$V_{DB} = 20 - 8.7 = 11.3V$

$Z_{BD} = \dfrac{3 \times 2}{3+2} + \dfrac{4 \times 5}{4+5} = 1.2 + \dfrac{20}{9}$

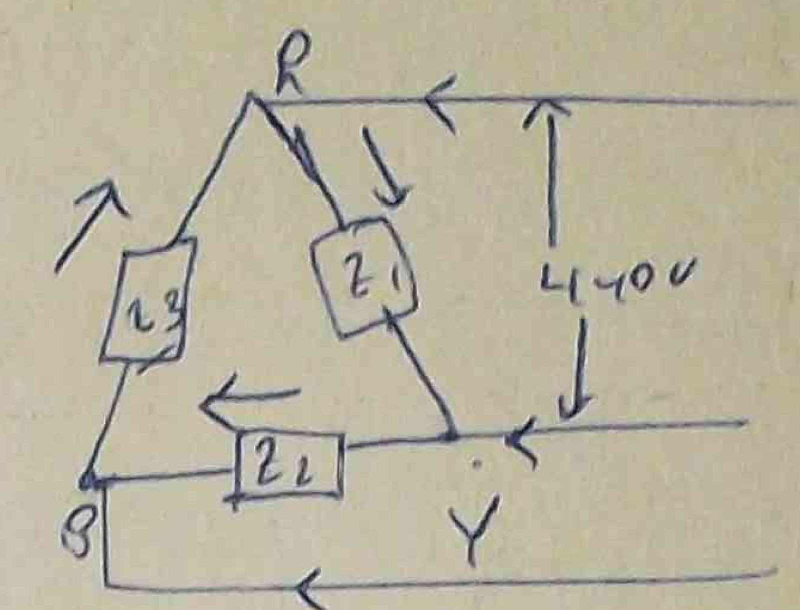
$= 1.2 + 2.225$

$= 3.425\Omega$

$Z_T = 50 + 3.425 = 53.425\Omega$

$I_{DB} = \dfrac{100}{53.425} = 1.872$ amp

* (4) 3φ 440V 50 c/s mesh connected system တွင် load များ၏ branch များမှာ RY = 20 kW unity pf YB = 30 kVA .8 pf lagging BR = 120 kVA 0.6 pf leading ဖြစ်သော် Line current များကို ရှာပါ။ phase sequence မှာ RYB ဖြစ်သည်။



$E_{RY} \, I_{RY} \cos\theta = 20 \times 10^3$

$440 \, I_{RY} \times 1 = 20{,}000$

$I_{RY} = \dfrac{20{,}000}{440} = 45.5$ amp

$\dot{I}_{RY} = 45.5 + J0$ amp

$E_{YB} \, I_{YB} \, \cancel{} = 30 \times 10^3$

$I_{YB} = \dfrac{30{,}000}{440} = 68.2$ amp

$\dot{I}_{YB} \; 68.2 \, (.8 - J.6)$

$= 54.5 - J40.8$ amp

$E_{BR} \, I_{BR} = 120 \times 10^3$

$I_{BR} = \dfrac{120{,}000}{440} = 273$ amp

$\dot{I}_{BR} = 273 \, (.6 + J.8)$

$= 163.8 + J218$ amp

$\dot{I}_R + \dot{I}_{BR} = \dot{I}_{RY}$

$\dot{I}_R = \dot{I}_{RY} - \dot{I}_{BR}$

$= 45.5 + J0 - (163.2 + J218)$

$= -118.3 - J218$

$= 248 \, \underline{|180 + 28.5}$

$= 248 \, \underline{|208.5}$ amp

$\dot{I}_Y + \dot{I}_{RY} = \dot{I}_{YB}$

$\dot{I}_Y = I_{YB} - I_{RY} = 54.5 - J40.8 - (45.5 + J0)$

$= 9 - J40.8 = 41.8 \, \underline{|-77}$

$$\dot{I}_{YB} + \dot{I}_B = \dot{I}_{BR}$$

$$\dot{I}_B = \dot{I}_{BR} - \dot{I}_{YB}$$

$$= 163.8 + J218 - (54.5 - J40.8)$$

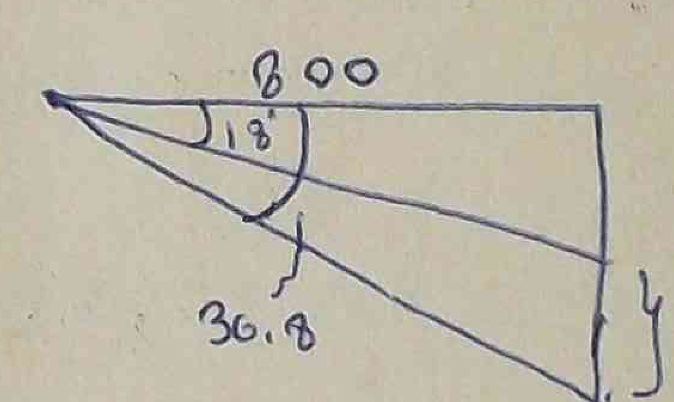
$$= 163.8 + J218 - 54.5 + J40.8$$

$$= 109.3 + J258.8$$

$$= 281 \angle 67.1 \text{ amp}$$

*(5) [illegible] 1000 kVA 0.8 pf lagging [illegible] load [illegible] 0.95 [illegible] reactance kVA [illegible] phase advancing Apparatus [illegible]
(က) supply [illegible] line power [illegible] constant [illegible]
(ခ) supply [illegible] kVA [illegible] constant [illegible]
[illegible] phase advancing apparatus [illegible]

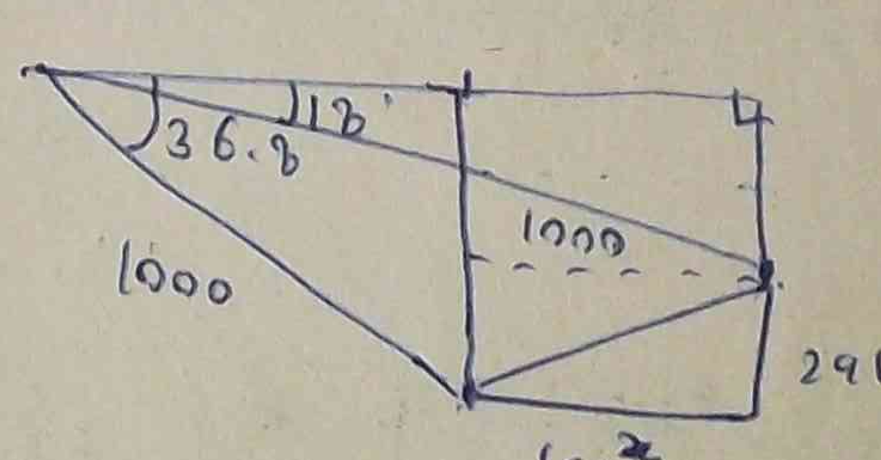
(က) supply line power constant [illegible]



Power $= 1000 \times .8 = 800$ kW

kVAR $= 800\,(\tan 36.8 - \tan 18^\circ)$
$= 800\,(.748 - .325)$
$= 800 \times .423$
$= 338$ kVAR

(ခ) supply kVA constant [illegible]



kVAR $= 1000\,(\sin 36.8 - \sin 18^\circ)$
$= 1000\,(.6 - .309)$
$= 1000 \times .291 = 291$ kVAR

(ဂ) kW $= 1000\,(\cos 18.8 - \cos 36.8)$
$= 1000\,(.95 - .8)$
$= 150$ kVAR

$\cot\theta = \dfrac{150}{291} = .516 \qquad \theta = \cot^{-1}.516 = 62.7^\circ \quad pf = .45$ leading

(၆) ရထား များ စတင်ရွေ့လျားချိန် ကာလ (Period) များ မှ ဖော်ပြ၍ ပုံဆွဲ၍ ရှင်းပြပါ။

200 tons ရှိသော ရထားတစ်စီး၏ rotational inertia သည် 10% ဖြစ်၍ tractive resistance 12 lb/ton သည် 2% မြင့်သော ... 45 mph ဖြစ်အောင် ... motor များ၏ ... ရှိသော ... တွက်ပါ။ ... (... ။)

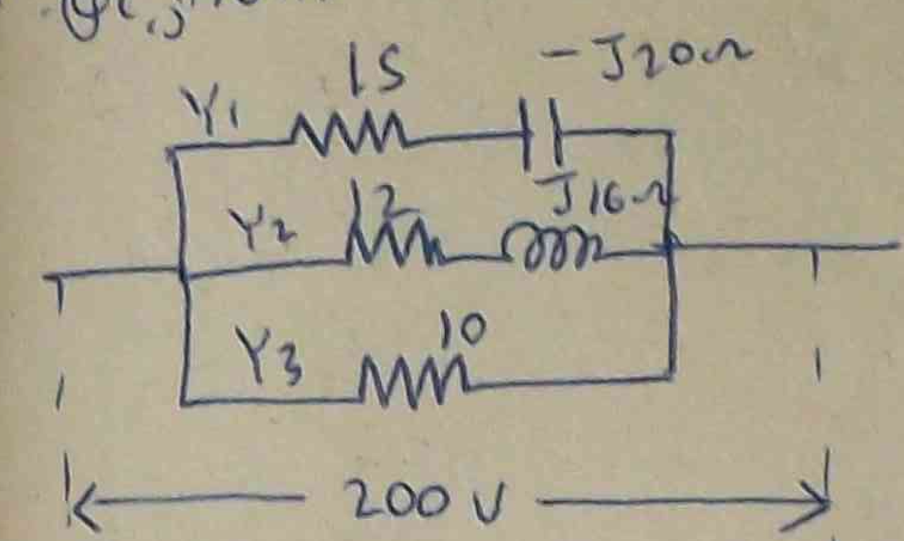
(၇) (က) Lighting system ၄ မျိုးကို ရှင်းလင်းဖော်ပြပါ။

(ခ) Photometer ဖြင့် illumination ကို မည်ကဲ့သို့ တိုင်းတာသည်ကို ရှင်းပြပါ။

(၈) ... 270' x 50' ... 15' ... illumination မှာ 3 FC ဖြစ်၍ space (height ratio) 1.5 ... utilisation factor 0.5 candle power depreciation 20% ဖြစ်ပြီး ... efficiency မှာ 74 lm/watt ဖြစ်သော ... voltage ... ပါ။

(1979) Final Exam

① အောက်ပါ impedance ၃ ခုတို့ကို 200 V 50 Hz supply ၌ ပြိုင်ဆက်ထားပါ $Z_1 = 15 - J20\,\Omega$ $Z_2 = 12 + J16\,\Omega$ $Z_3 = 10 + J0\,\Omega$ circuit ၏ စုစုပေါင်း admittance, current, power factor နှင့် သုံးစွဲသော power တို့ကို ckt ပုံ၊ admittance vector ပုံ ဆွဲပြပါ။



$$Y_1 = \frac{15}{15^2+20^2} + J\frac{20}{15^2+20^2}$$

$$= \frac{15}{625} + J\frac{20}{625}$$

$$= .024 + J.032\ \mho$$

$$Y_2 = \frac{12}{12^2+16^2} - J\frac{16}{12^2+16^2}$$

$$= \frac{12}{400} - J\frac{16}{400}$$

$$= .03 - J.04\ \mho$$

$$Y_3 = \frac{1}{10} \pm J0 = .1 \pm J0$$

$$Y_t = Y_1 + Y_2 + Y_3$$

$$= .024 + J.032 + .03 - J.04 + .1 \pm J0$$

$$= .154 - J.008$$

$$= .154\ \angle{-2.98}\ \mho$$

Current $= 200 \times .154 = 30.8$ amp

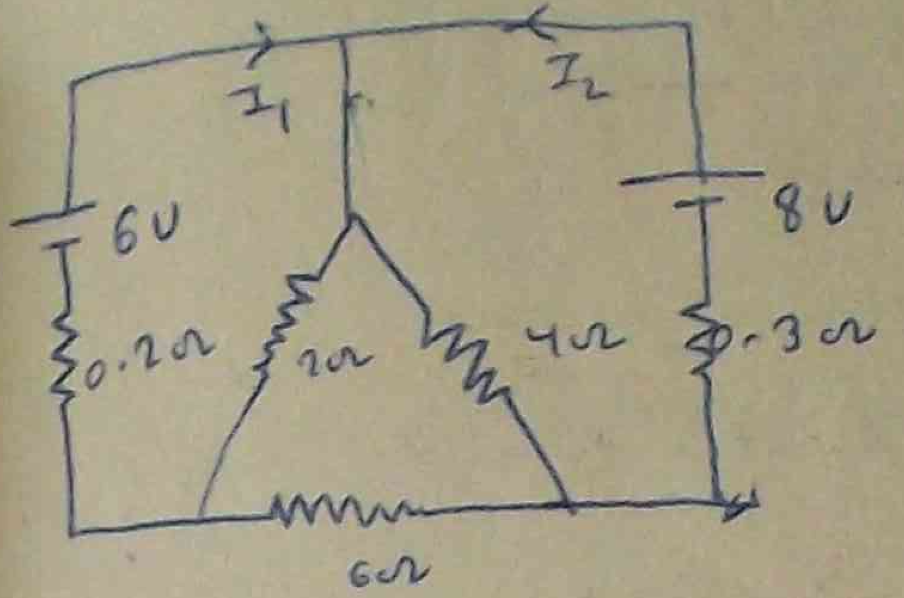
$\text{Pf} = \cos 2.98 = .997$ lagging

Power $= EI\cos\theta = 200 \times 30.8 \times .997$

$= 6160 \times .997$

$= 6150$ watts

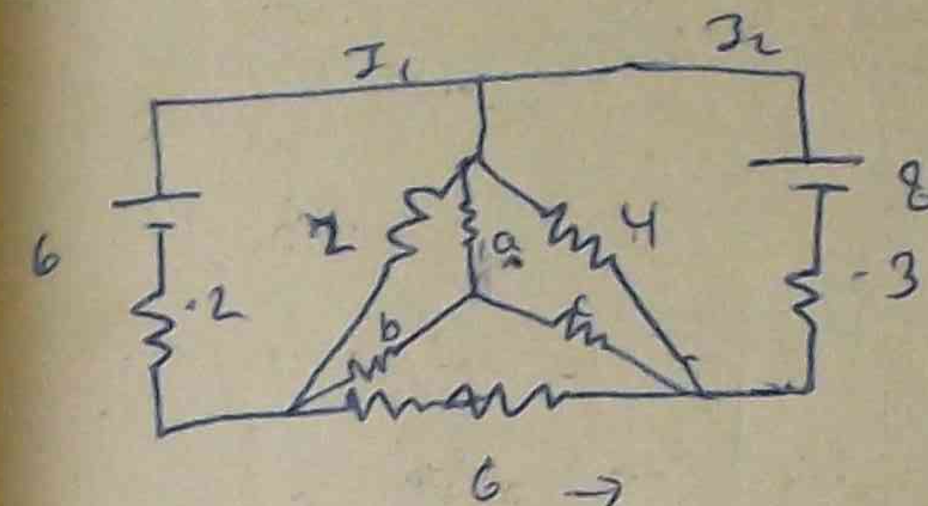
(2)



Super position Theoremဖြင့်

I_1, I_2 တန်ဖိုးကို ရှာပါ။

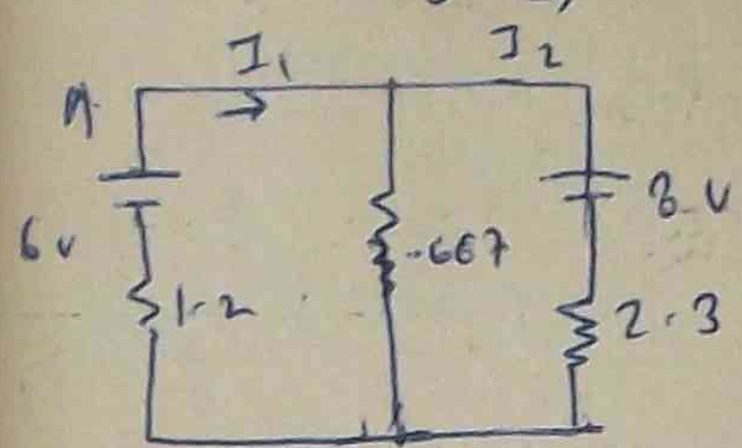
Direction ကိုပြပေးပါ။



$a = \frac{2 \times 4}{12} = .667$

$b = \frac{2 \times 6}{12} = 1\Omega$

$c = \frac{6 \times 4}{12} = 2\Omega$



8v short လုပ်

$Z_t = 1.2 + \frac{.667 \times 2.3}{.667 + 2.3}$

$= 1.2 + \frac{1.532}{2.967}$

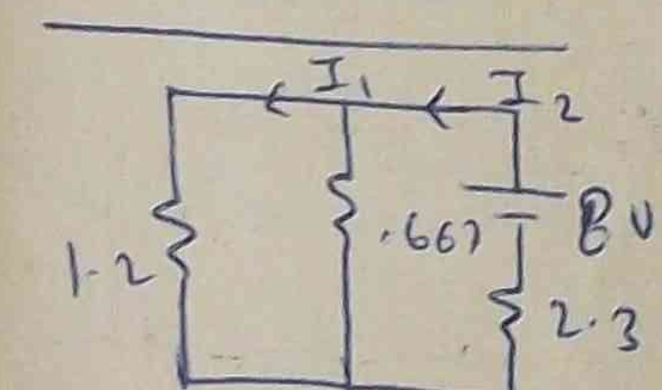
$= 1.2 + .517 = 1.717\Omega$

$I_1 = \frac{6}{1.717} = \overrightarrow{3.49}$ amp

$I_2 = 3.49 \times \frac{.667}{2.967}$

$= \frac{2.325}{2.967} = \overrightarrow{.783}$ amp

6v ကို short လုပ်



$Z_T = 2.3 + \frac{1.2 \times .667}{1.2 + .667}$

$= 2.3 + \frac{.801}{1.867}$

$= 2.3 + .428$

$= 2.728\Omega$

$I_2 = \frac{8}{2.728} = \overleftarrow{2.93}$ amp

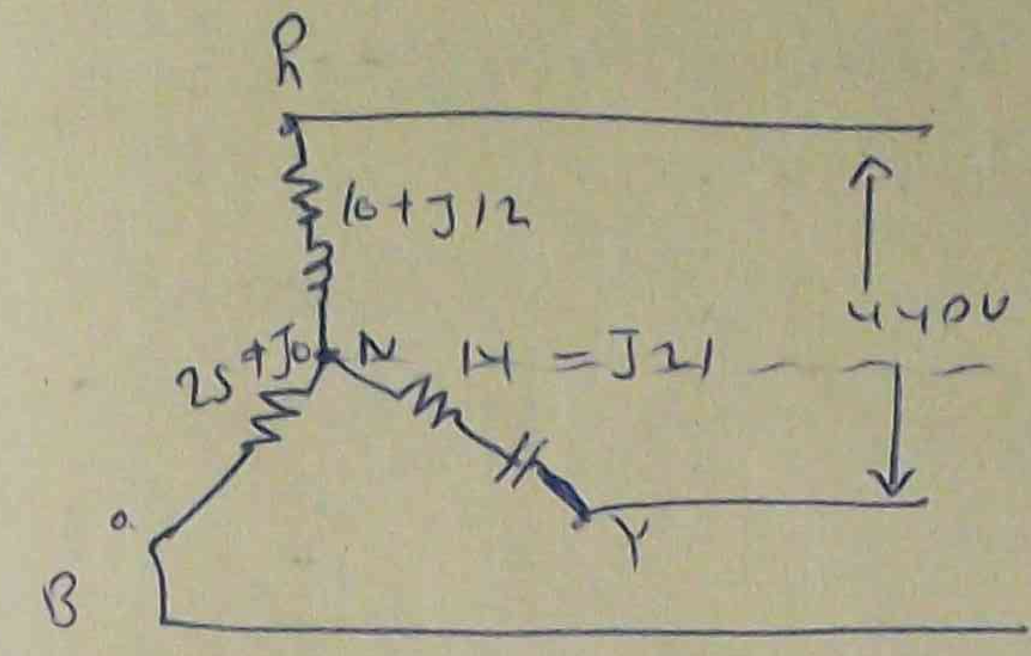
$I_1 = \frac{2.93 \times .667}{1.867} = \frac{1.95}{1.867} = \overleftarrow{1.045}$ amp

$I_1 = \overrightarrow{3.49} + \overleftarrow{1.045}$

$= \overrightarrow{2.445}$ amp

$I_2 = \overrightarrow{.783} + \overleftarrow{2.93} = \overleftarrow{2.147}$ amp

(3) 440V 3φ 3 wire system ရှိ ပေးထားသော load တစ်ခုတွင် ~~neutral wire ... current~~ ... E_N ကိုရှာပါ။
R နှင့် N ကြား $16+J12\,\Omega$ Y နှင့် N ကြား $14-J21\,\Omega$
B နှင့် N ကြား $25+J0$ phase sequence RYB.



$$E_{phR} = \frac{440}{1.7321} = 254\,V$$

$$E_N = \frac{E_{phR} \times Y_{RN} + E_{phY}\, Y_{YN} + E_{phB}\, Y_{BN}}{Y_{RN} + Y_{YN} + Y_{BN}}$$

$$= \frac{254\angle 0 \times \frac{1}{16+J12} + 254\angle -120 \times \frac{1}{14-J21} + 254\angle -240 \times \frac{1}{25+J0}}{\frac{1}{16+J12} + \frac{1}{14-J21} + \frac{1}{25}}$$

$$= \frac{\frac{254\angle 0}{20\angle 36.9} + \frac{254\angle -120}{25.2\angle -56.3} + \frac{254\angle -240}{25\angle 0}}{\frac{1}{20\angle 36.9} + \frac{1}{25.2\angle -56.3} + \frac{1}{25}}$$

$$= \frac{12.7\angle -36.9 + 10.08\angle -63.7 + 10.15\angle -240}{.05\angle -36.8 + .0397\angle 56.3 + .04}$$

$$= \frac{12.7\cos 36.9 - J12.7\sin 36.9 + 10.08\cos 63.7 - J10.08\sin 63.7 - 10.15\cos 60 + J\,10.15\sin 60}{.05\cos 36.8 - J.05\sin 36.8 + .0397\cos 56.3 + J.0397\sin 56.3 + .04}$$

$$= \frac{10.15 - J7.63 + 4.47 - J9.05 - 5.075 + J8.8}{.04 - J.03 + .022 + J.033 + .04}$$

$$= \frac{9.545 - J7.88}{.102 + J.003} = \frac{12.38\angle -39.6}{.102\angle 1.685}$$

$$= 121.2\angle -41.285 \text{ Volts}$$

$\dot{E}_N = 121.2 \cos 41.2° - J 121.2 \ldots$

$= 121.2 \times .752 - J\,121.2 \times .66$

$= 91.2 - J\,80$ volts

$E_{RN} = E_{phR} - E_N$

$= 254\angle 0 - (91.2 - J\,80)$

$= 254 + J0 - 91.2 + J\,80$

$= 162.8 + J\,80 = 181.5 \angle 26.2$ volts

$E_{YN} = E_{phY} - E_N$

$= 254\angle -120 - 91.2 + J\,80$

$= 254\cos 60 - J\,254\sin 60 - 91.2 + J\,80$

$= -127 - J\,220 - 91.2 + J\,80$

$= -218.2 - J\,140$

$= 259 \angle 180 + 32.7$

$= 259 \angle 212.7$ volts

$E_{BN} = E_{phB} - E_N$

$= 254\angle -240 - 91.2 + J\,80$

$= 254(-\cos 60 + J\sin 60) - 91.2 + J\,80$

$= -127 + J\,220 - 91.2 + J\,80$

$= -218.2 + J\,300$

$= 371 \angle 180 - 53.95$ volts

$= 371 \angle 126.05$ volts

$I_R = \dfrac{181.5\angle 26.2}{20\angle 36.9} = 9.07\angle -10.7$ amp

$\dot{I}_R = 9.07(\cos 10.7 - J\sin 10.7)$

$= 8.92 - J\,1.68$ amp

$\dfrac{\quad}{25.2 \angle -56.3}$

$I_Y = 0 - J10.27$ amp

$I_B = \dfrac{371 \angle 126.05}{25 \angle 0} = 14.83 \angle 126.05$ amp

$\dot{I}_B = 14.83\,(-\cos 53.95 + J\sin 53.95)$

$= -8.74 + J12$ amp

$\dot{I}_N = \dot{I}_R + \dot{I}_Y + \dot{I}_B$

$= 8.92 - J1.68 + 0 - J10.27 - 8.74 + J12$

$= .18 + J.05$

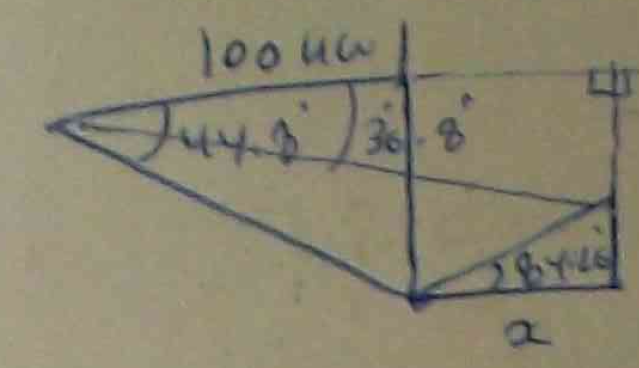
$= .1868 \angle 15.5$ amp

(4) Alternator [illegible] 0.8 pf lagging [illegible] 800 kw [illegible] [illegible] units pf [illegible] syn: motor [illegible] Armature current [illegible] (cm) Alternator [illegible] syn: motor [illegible] Power [illegible] (a) [illegible] syn: motor effcy: 90% [illegible] motor [illegible] HP [illegible] developed [illegible] (b) syn: motor [illegible] pf [illegible] running [illegible]

(5) 1 M.v.1 ϕ system [illegible] load [illegible] 100 kw [illegible] pf 0.71 ~~leading~~ lagging [illegible] pf [illegible] 0.9 lagging [illegible] 0.1 leading pf [illegible] phase advancing apparatus [illegible] load [illegible] Apparatus [illegible] supply current [illegible]

★ (7) 100 tons [illegible] motor [illegible] motor [illegible] shaft Torque [illegible] 1.27% up gradient [illegible] 1000 lb/t [illegible] gearing effcy: 94% wheel 100 [illegible] 18 mph [illegible] 25 [illegible] rotational inertia 8% wheel dia 40" gear ratio: 3.5 Tractive [illegible] 11 lb/ton [illegible]

(5)



$100 \tan 44.8 = (100+x) \tan 36.8 + x \tan 34.26'$

$99.3 = (100+x).748 + 9.95x$

$99.3 = 74.8 + .748x + 9.95x$

$10.698x = 24.5$

$x = 2.29$ kw

$kVA = \dfrac{2.29}{\cos 84.26} = \dfrac{2.29}{.1} = 22.9$ kVA

$\therefore$ Total kw $= 100 + 2.29 = 102.29$ kw

$EI\cos\theta = 102.29 \times$

$I = \dfrac{102.29}{1 \times .8} = \dfrac{102.29}{.8} = 128$ amp

(6) [illegible] Bridge [illegible] Bridge [illegible] circuit [illegible] AC Bridge ABCD [illegible] Impedance [illegible]

[illegible] AB [illegible] unknown coil [illegible] Regulator 600 [illegible]

[illegible] BC [illegible] No loss 1 μFd condenser [illegible] 20 [illegible] series [illegible]

[illegible] CD - No loss 0.5 μFd condenser

[illegible] DA - Non reactive resistor 2850 [illegible]

50 ~ AC supply voltage [illegible] balance [illegible] detector [illegible] unknown coil [illegible] resistance [illegible] inductance [illegible] coil Impedance [illegible]

(8) MSCP [illegible] MHSC [illegible]

[illegible] 160' [illegible] 40' [illegible]

[illegible] 20' [illegible]

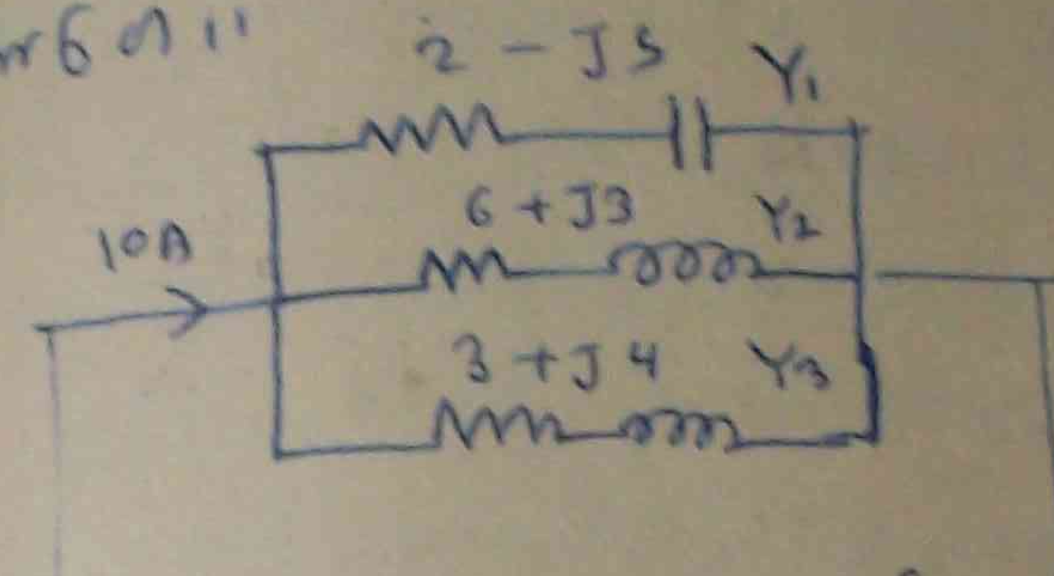
[illegible]

[illegible] illumination [illegible] 0.75 FC [illegible]

[illegible] illumination [illegible]

(1981) ZSN MIDTERM EXAM

① Impedor (၃)ခုရှိ၍ $Z_1 = 2 - J5\,\Omega$ $Z_2 = 6 + J3\,\Omega$ – $Z_3 = 3 + J4\,\Omega$ တို့ဖြစ်ကြ၏။ AC supply တခုတွင် parallel ဆက်ထားရာ line current 10 Amp ရှိလျှင် Impedor တခုစီ၏ current များကိုရှာပါ။ ၎င်းတို့၏ admittance vector စုစုပေါင်းကိုဖော်ပြပါ။ စုစုပေါင်း admittance, conductance, susceptance တို့ကိုလည်းရှာပါ။ circuit ပုံကိုဆွဲပြပါ။



$$Y_1 = \frac{2}{2^2+5^2} + J\frac{5}{2^2+5^2} = \frac{2}{29} + J\frac{5}{29} = .069 + J.1725$$
$$= .1855 \angle 68.17\ ℧$$

$$Y_2 = \frac{6}{6^2+3^2} - J\frac{3}{6^2+3^2} = \frac{6}{45} - J\frac{3}{45} = .1333 - J.0667$$
$$= .149 \angle -26.6\ ℧$$

$$Y_3 = \frac{3}{3^2+4^2} - J\frac{4}{3^2+4^2} = \frac{3}{25} - J\frac{4}{25} = .12 - J.16$$
$$= .2 \angle -53.1\ ℧$$

$$Y_t = Y_1 + Y_2 + Y_3 = .069 + J.1725 + .1333 - J.0667 + .12 - J.16$$
$$= .3223 - J.0542$$
$$= .3265 \angle -9.55\ ℧$$

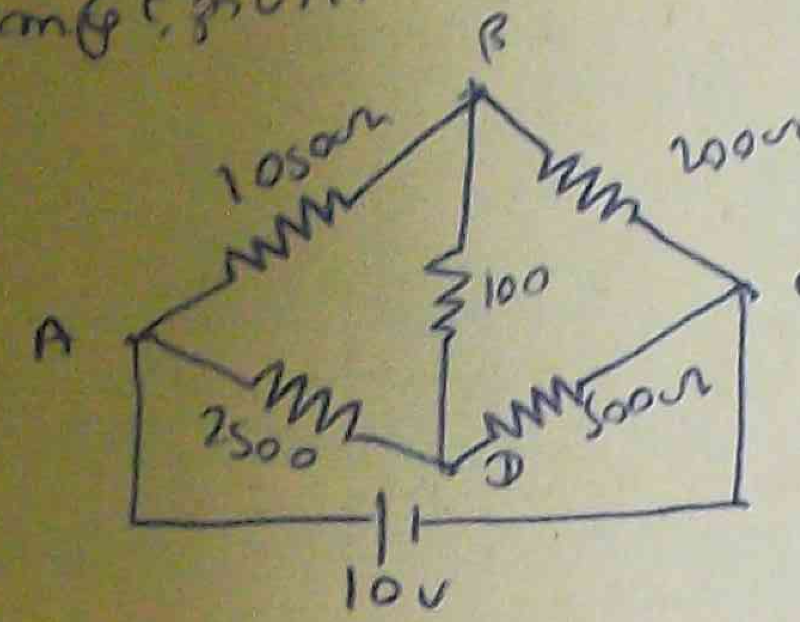
$$I = E\,Y_t$$
$$10 = E \times .3265 \angle -9.55$$
$$E = \frac{10}{.3265 \angle -9.55} = 30.65 \angle 9.55 \text{ volts}$$

$$I_1 = .1855 \times 30.65 = 5.7 \angle 77.72 \text{ amp}$$
$$I_3 = .2 \angle -53.1 \times 30.65 \angle 9.55 = 6.13 \angle -43.55 \text{ amp}$$
$$I_2 = .149 \angle -26.6 \times 30.65 \angle 9.55 = 4.57 \angle -17.05 \text{ amp}$$

$$Y_t = .3265 \cos 9.55 - J.3265 \sin 9.55$$
$$= .3265 \times .986 - J.3265 \times .166$$
$$= .322 - J.0543\ ℧$$

conductance = .322 ℧ susceptance = .0543 ℧

* (3) Thevenin's theorem [illegible] $AB = 1050\,\Omega$ $BC = 200\,\Omega$ $CD = 500\,\Omega$ wheatstone Bridge ABCD [illegible] 10V Battery [illegible] A C [illegible] $DA = 2500\,\Omega$ [illegible] Galvanometer [illegible] Galvanometer [illegible] $100\,\Omega$ [illegible] current [illegible] G meter [illegible] sensitivity $0.5\,\mu A/mm$ [illegible]



[illegible] $I_{ABC} = \dfrac{10}{1250}$ amp

$V_{AB} = \dfrac{10}{1250} \times 1050 = \dfrac{10500}{1250} = 8.4\,V$

$I_{ADC} = \dfrac{10}{3000}$ amp

$I_{AD} = \dfrac{10}{3000} \times 2500 = \dfrac{25000}{3000} = 8.33\,V$

$V_{BD} = 8.4 - 8.33 = .07\,V =$

$$Z_{BD} = \frac{1050 \times 200}{1250} + \frac{2500 \times 500}{3000}$$

$$= \frac{210{,}000}{1250} + \frac{1250000}{3000}$$

$$= 168 + 417 = 585\,\Omega \qquad Z_T = 685\,\Omega$$

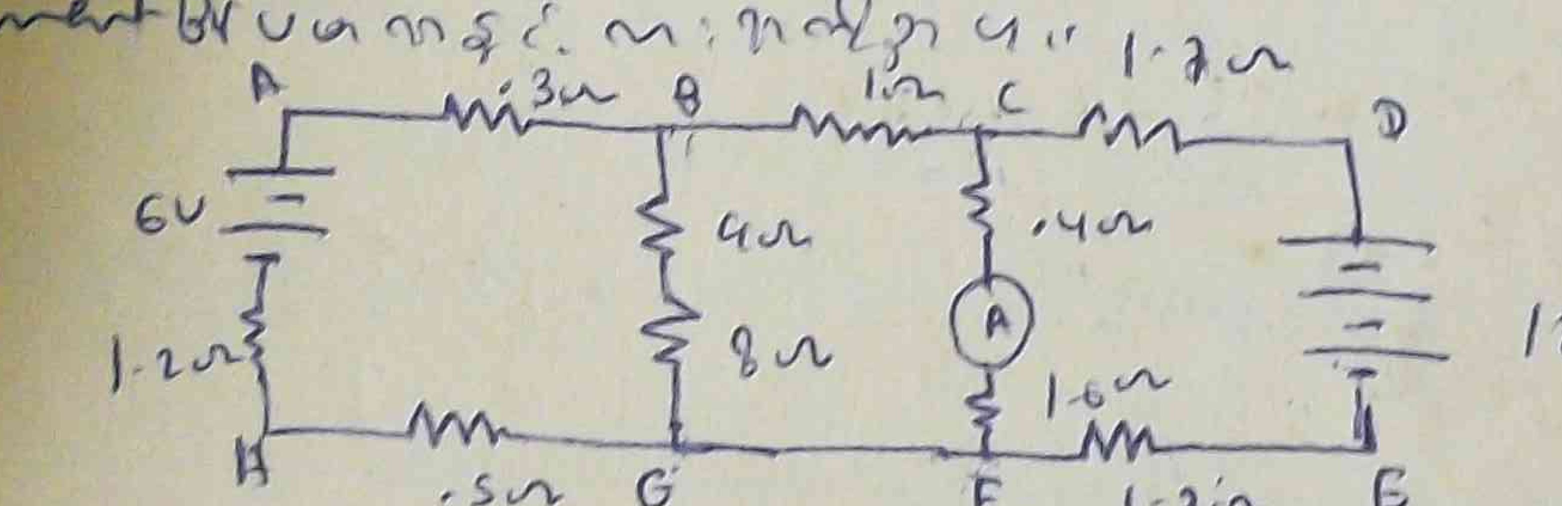
Z_T $\quad I_{BD} = \dfrac{.07}{685} = \dfrac{.07}{.685} \times 10^{-3} = \cancel{.0102}\,mA$ $.102\,mA$

$= 102.0\,\mu A$

Pointer [illegible] $= \dfrac{102.0}{.5} = \cancel{20.4\,mm} = \cancel{2.04\,cm}$

$204\,mm = 20.4\,cm = \cancel{2.04\,cm}$ (Ans)

* (3) superposition theorem [illegible] Ammeter [illegible] current [illegible] $1.7\,\Omega$



12V [illegible] short [illegible] $R_{BF} = 1 + \dfrac{3 \times 2}{3+2} = 1 + \dfrac{6}{5} = 2.2\,\Omega$

$R_{BG} = \dfrac{12 \times 2.2}{14.2} = \dfrac{26.4}{14.2} = 1.26\,\Omega$

$R_T = .2 + 1.26 + 1.2 = 2.66\,\Omega$

$R_T = 3.86\,\Omega$

$I_t = \dfrac{6}{3.86} = 1.553$ amp

$I_{BC} = \dfrac{1.553 \times 12}{14.2} = \dfrac{18.65}{14.2} = 1.313$ amp

$I_{CF} = 1.313 \times \dfrac{3}{5} = 1.313 \times .6 = .788$ amp ↓

6V [illegible] short [illegible] $R_{CG} = 1 + \dfrac{12 \times 2}{14} = 1 + \dfrac{24}{14} = 1 + 1.715 = 2.715\,\Omega$

$R_{CF} = \dfrac{2 \times 2.715}{4.715} = \dfrac{5.43}{4.715} = 1.15\,\Omega$

$R_T = 1.15 + 3 = 4.15\,\Omega$

$I_t = \dfrac{12}{4.15} = 2.89$ amp

$I_{CF} = 2.89 \times \dfrac{2.715}{4.715} = 1.665$ ↓ amp

$I = 2.45$ [illegible]

④ 3φ 4wire 440v system [illegible] 3φ .8 pf lagging balanced load

load [illegible] (a) 50kw 3φ .8 pf lagging balanced load [illegible] 10kw at unity pf

(b) lighting load [illegible] R [illegible] N [illegible] 10kw at unity pf

Y " N 12 " "

B " N 25 " "

phase sequence RYB [illegible] neutral current [illegible] main line current [illegible] [illegible]

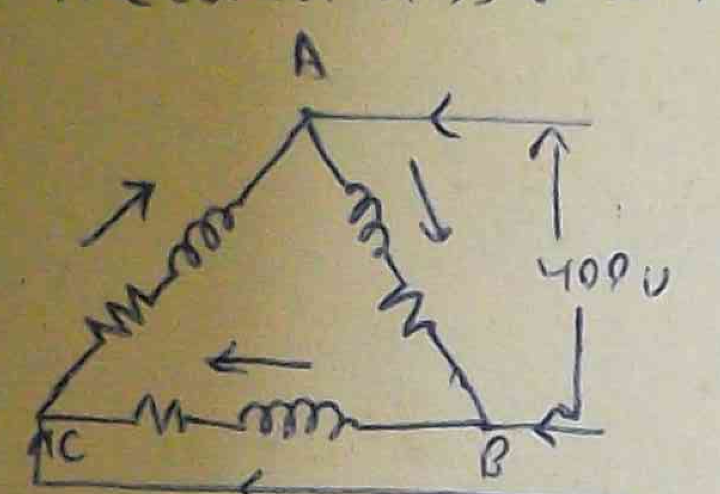
⑤ 3φ 3wire 400v symmetrical supply line [illegible] Δ [illegible]

unbalanced load [illegible] $Z_{AB} = 12 + J16\,\Omega$ $Z_{BC} = 69.2 + J40\,\Omega$

$Z_{CA} = 34.8 + J20\,\Omega$ phase sequence ABC [illegible] phase [illegible]

line current [illegible] power [illegible]

V_{AB} Ref: [illegible]



$$I_{AB} = \frac{400\angle 0}{12 + J16} = \frac{400\angle 0}{20\angle 53.1} = 20\angle -53.1 \text{ amp}$$

$$I_{AB} = 12 - J16 \text{ amp} = \cancel{20\angle -53.1}$$

$$I_{BC} = \frac{400\angle -120}{79.8\angle 30.1} = 5.01\angle -150.1 = -4.34 - J2.505 \text{ amp}$$

$$I_{CA} = \frac{400\angle -240}{40.2\ \angle 29.4} = 9.97\angle -270 = 0 + J9.97 \text{ amp}$$

$I_{CA} + I_A = I_{AB}$ $\quad I_A = I_{AB} - I_{CA} = 12 - J16 - (0 + J9.97)$

$I_{AB} + I_B = I_{BC}$ $\quad = 12 - J25.97 = 28.6\angle -65.2$ amp

$\therefore I_B = I_{BC} - I_{AB}$

$$= -4.34 - J2.505 - 12 + J16$$

$$= -16.34 + J13.495 = 21.15\angle 140.45 \text{ amp}$$

$I_{BC} + I_C = I_{CA}$ $\quad I_C = 0 + J9.97 + 4.34 + J2.505$

$$= 4.34 + J12.475 = 13.2\angle 70.8$$

$$\text{Total power} = 20^2 \times 12 + (5.01)^2 \times 69.2 + (9.97)^2 \times 34.8$$

$$= 9.99\text{kw}$$

*

⑥ ~~3φ 3wire~~ 125v 4 A discharge lamp [illegible] unity pf [illegible]

250v 50~ line [illegible]

[illegible] resis: [illegible] choking coil [illegible] inductance

[illegible] unity pf [illegible] capacitor [illegible]

only pf
ind: 0

$R = \frac{125}{4} = 31.25\ \Omega$ $\quad Z_2 = 31.25 + Jx\ \Omega$

$$I_2 = \frac{250}{31.25 + Jx} \text{ amp}$$

$I_1^2 R_1 = I_2^2 R_2$ (watt [illegible])

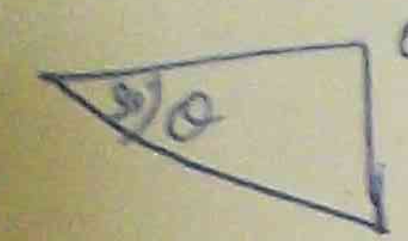
$$4^2 R_1 = \left(\frac{250}{31.25 + Jx}\right)^2 R_2 \quad (31.25 + Jx)^2 = \left(\frac{250}{4}\right)^2$$

~~Ic = 61500~~

$$31.25 + Jx = 62.5$$

$$\sqrt{31.25^2 + x^2} = 62.5 \quad \therefore x = 54\ \Omega$$

$$L = \frac{54}{314} = .172 \text{ Henary}$$



$\theta = \tan^{-1}\frac{31.25}{54} = \cot^{-1} .578 = 60^\circ$

$\cos 60^\circ = .5$ ~~.866~~

~~kVAR~~ watt = 115 × 4 = 500 watts

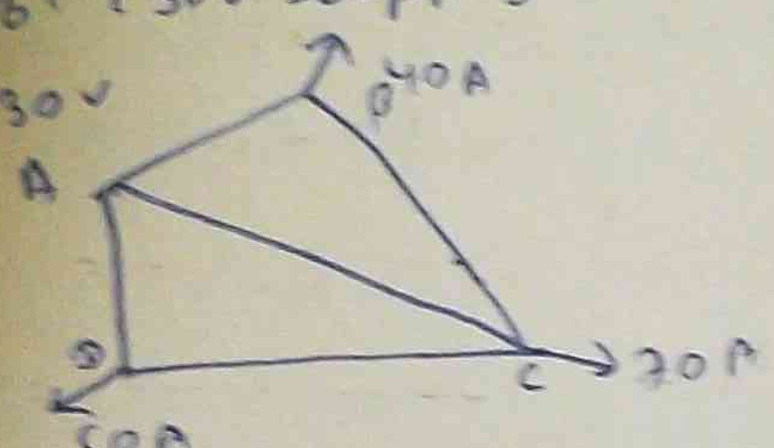
VAR = 500 tan 60° = 500 × 1.734 = 866 VAR

$E_{ph}^2 \omega C_0 = 866$

$C_0 = \frac{866}{(250)^2 \times 314} = \frac{866}{61500 \times 314}$

$C_0 = \frac{866}{19620000} = \frac{866}{1962} \times 10^{-6} = 44.2\,\mu F$

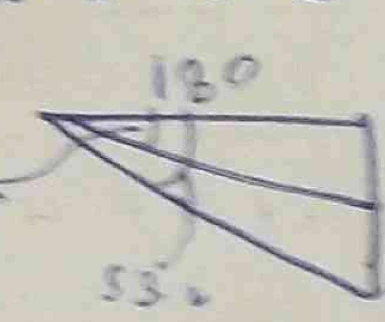
⑦ [illegible] interconnected ring distributor ၏ Feeder current [illegible] sectional 2wire [illegible]
AB = .05Ω BC = .05Ω CA = 0.1Ω DA = .05Ω AC = 0.1Ω
A [illegible] 230V supply [illegible] load voltage [illegible]



[illegible]

*⑧ 3300 V 3φ 50Hz induction motor [illegible] load [illegible] pf 0.6 [illegible]
300 kVA [illegible] load [illegible] pf 0.95 lag [illegible]
Δ [illegible] "C" [illegible] pf [illegible]
Load [illegible] condenser [illegible]
[illegible] load kVA [illegible] pf [illegible] vector [illegible]

kw = 300 cos θ = 300 × .6 = 180 kw



kVARd = 180 (tan 53.2 − tan 18)
= 180 (1.338 − .325)
kVARd = 180 × 1.013 = 182.3 kVAR

$E_{pn}^2 \omega C_0 = \frac{kVA \times 10^3}{3}$

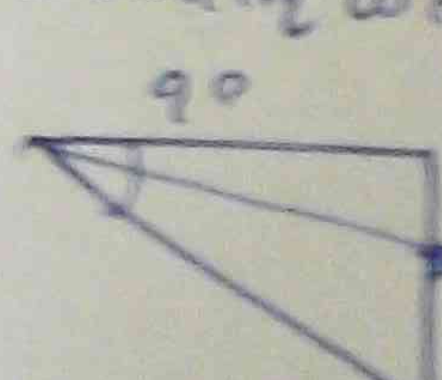
$(3300)^2 \times 314 \times C_0 = \frac{182.3 \times 10^3}{3}$

$C_0 = \frac{182300}{3 \times 314 \times 10890000}$

$= \frac{182300}{942 \times 10.89 \times 10^6}$

$= \frac{182300}{10240}\,\mu F = 17.8\,\mu F$

Load [illegible] = $\frac{180}{2}$ = 90 kw



kVAR₁ = 90 tan 53.2
= 90 × 1.338 = 120.5 kVAR

kVAR₂ = 120.5 − 182.3 = −61.8

kVA = 90 + J61.8 = 109.2 ∠34.5 kVA

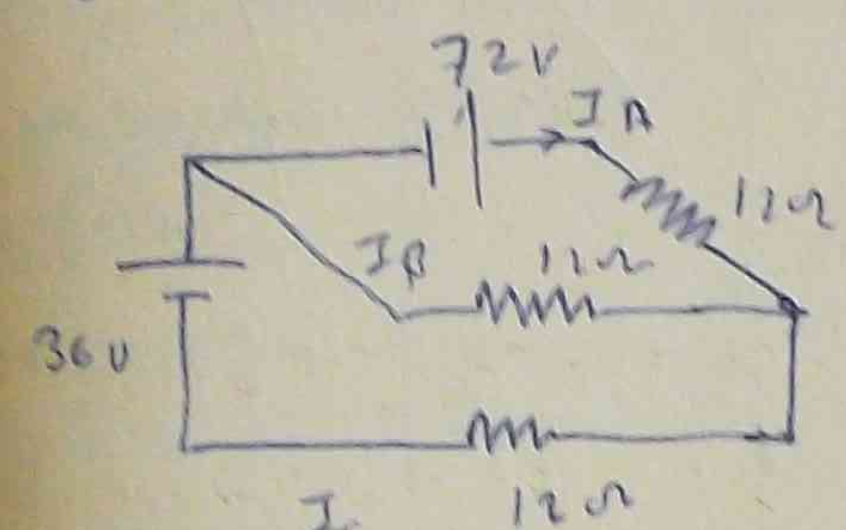
pf = cos 34.5 = .825 leading

(1980) ISN MID TERM EXAM

① [illegible] Impedance [illegible] $Z_1 = 8 + j6\Omega$ $Z_2 = 12 - j16\Omega$ [illegible] Z_1, Z_2 [illegible] parallel [illegible] $Z_3 = 3.2 - j14.4\Omega$ [illegible] Z_1, Z_2 [illegible] series [illegible] 200 V [illegible] supply [illegible] (a) Total admittance (Y) conductance (G) susceptance (B) current (b) [illegible] power [illegible] admittance vector [illegible] (c) [illegible]

② ABCD wheatstone bridge [illegible] AB = 1050 Ω [illegible] BC = 200 Ω [illegible] CD = 500 Ω [illegible] DA = 2500 Ω [illegible] 100 Ω [illegible] Galvanometer [illegible] Thevenin theorem [illegible] Galvanometer current [illegible] sensitivity [illegible] 0.5 μA/mm [illegible] battery [illegible] supply [illegible] ([illegible])

③



[illegible] I_A, I_B [illegible] I_C [illegible] Superposition theorem [illegible]

72 V [illegible] short [illegible] $Z_T = 12 + 6 = 18\Omega$ $I_t = \frac{36}{18} = 2$ amp

$\therefore I_C = \overleftarrow{2}$ amp

$I_A = I_B = \overrightarrow{1}$ amp

36 V [illegible] short [illegible] $Z_T = 12 + 6 = 18\Omega$

$I_t = \frac{72}{18} = 4$ amp

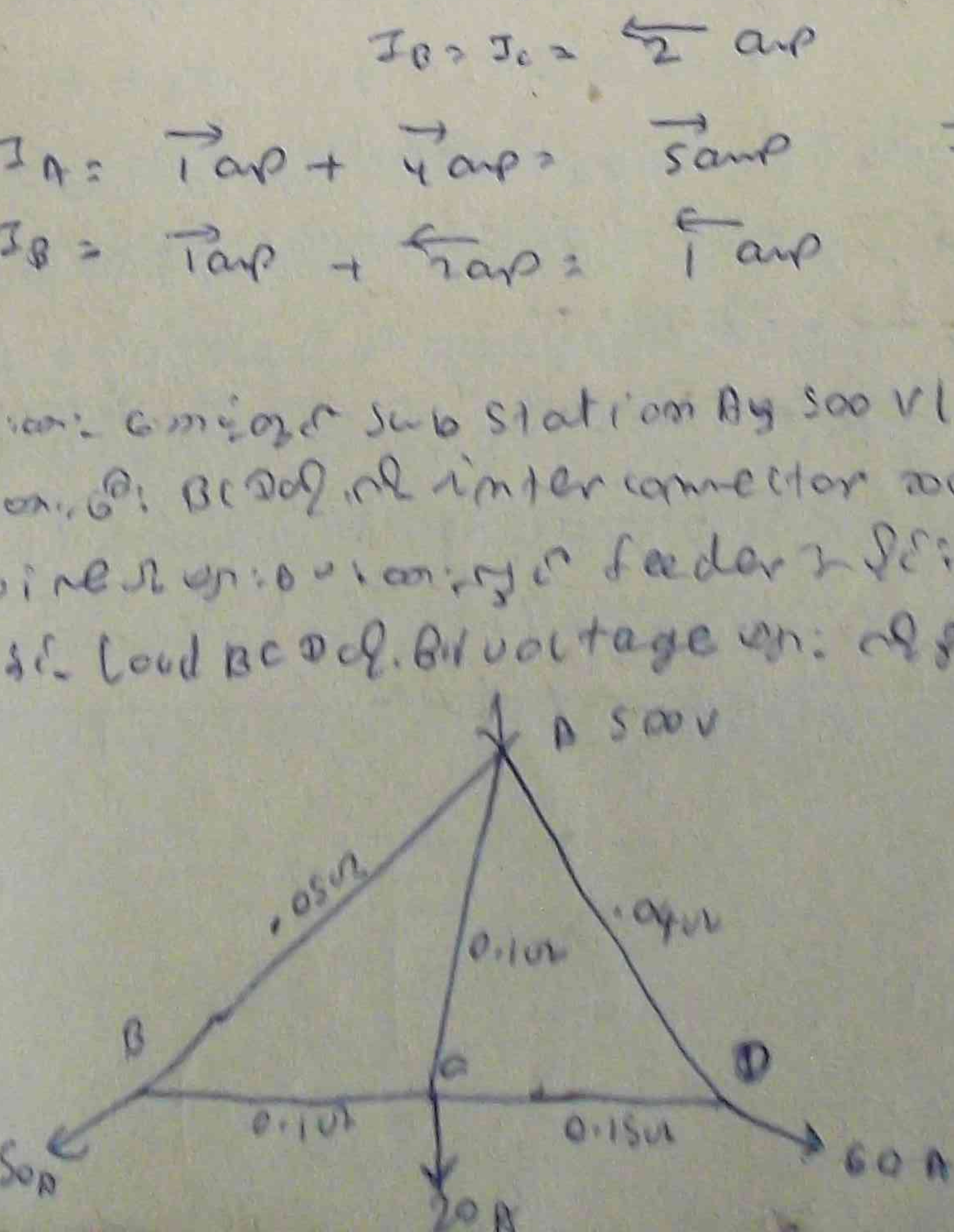
$I_A = \overrightarrow{4}$ amp

$I_B = I_C = \overleftarrow{2}$ amp

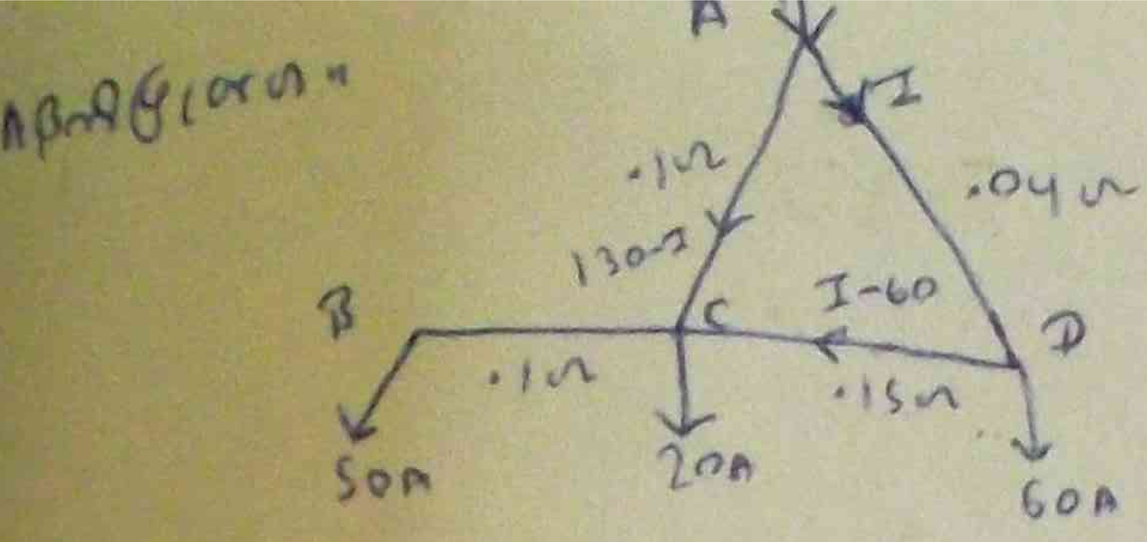
$I_A = \overrightarrow{1\text{ amp}} + \overrightarrow{4\text{ amp}} = \overrightarrow{5\text{ amp}}$ $I_C = \overleftarrow{2\text{ amp}} + \overleftarrow{2\text{ amp}}$

$I_B = \overrightarrow{1\text{ amp}} + \overleftarrow{2\text{ amp}} = \overleftarrow{1\text{ amp}}$ $= \overleftarrow{4\text{ amp}}$

* ④ [illegible] Sub station A [illegible] 500 V load B C D [illegible] supply [illegible] BC [illegible] interconnector [illegible] sectional [illegible] feeder [illegible] current [illegible] load B C D [illegible] voltage [illegible]



[illegible]



$$Z_T = .05 + .1 + \frac{.1 \times .19}{.1 + .19}$$

$$= .15 + \frac{.019}{.29}$$

$$= .15 + .0655 = .2155\,\Omega$$

$$.04I + .15(I - 60) = .1(130 - I)$$

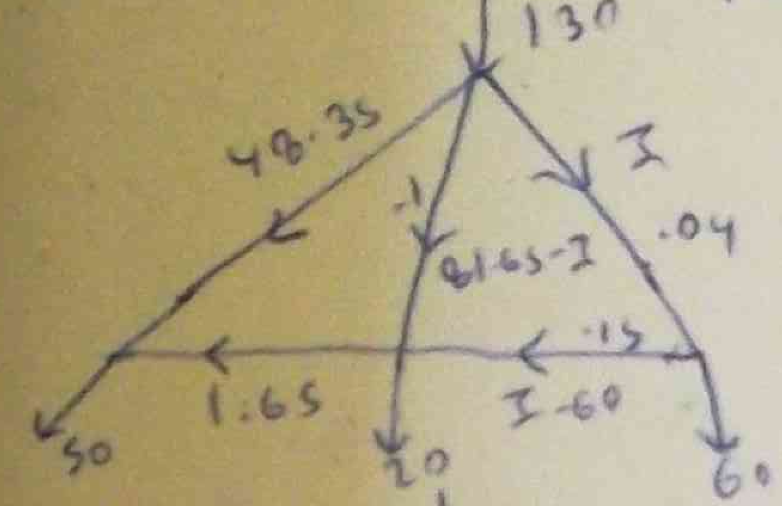
$$.04I + .15I - 9 = 13 - .1I$$

$$.29I = 22 \qquad I = \frac{22}{.29} = \frac{220}{2.9} = 75.8\text{ amp}$$

$$V_{AD} = 50 \times .1 + (130 - 75.8) \times .1$$

$$= 5 + 5.42 = 10.42\text{ volts}$$

$$I_{AB} = \frac{10.42}{.2155} = 48.35\text{ amp}$$

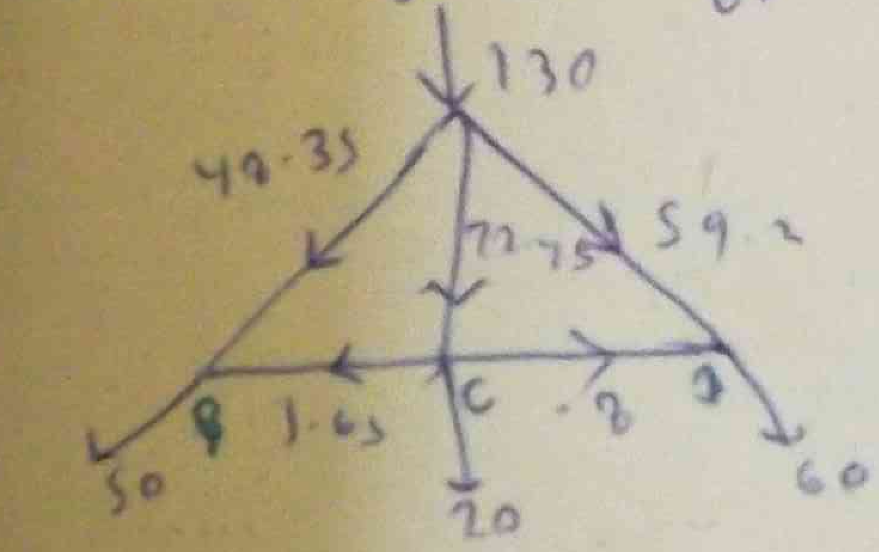


$$.04I + .15(I - 60) = .1(81.65 - I)$$

$$.04I + .15I - 9 = 8.165 - .1I$$

$$.29I = 17.165$$

$$I = \frac{171.65}{2.9} = 59.2\text{ amp}$$



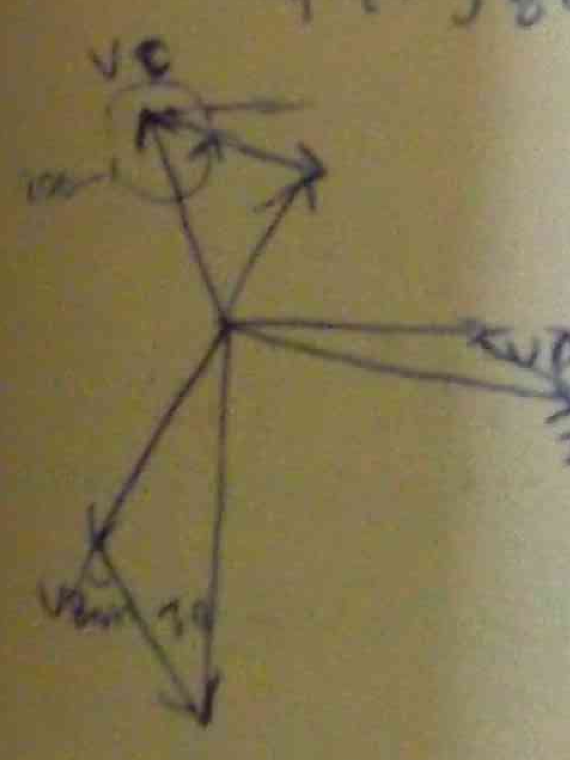
$$V_B = 500 - 48.35 \times .05 = 497.5\,V$$

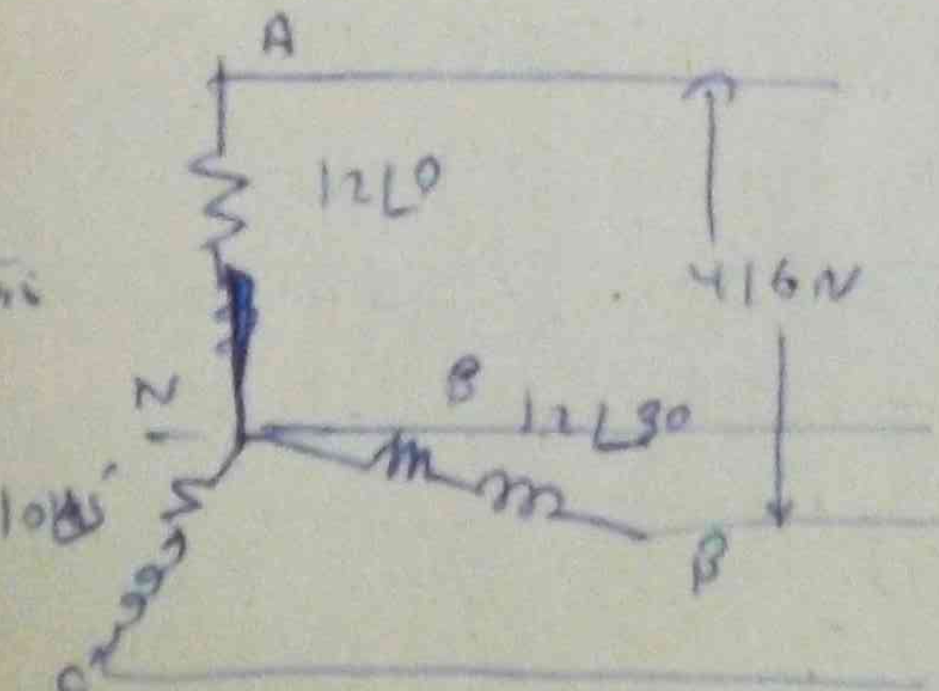
$$V_C = 500 - 27.4 \times .1 = 497.26\,V$$

$$V_D = 500 - 59.2 \times .04 = 497.64\,V$$

*

(5) 3ϕ 4 wire 416 V CBA supply [illegible] 4 wire star load [illegible] $Z_A = 12\angle 0\,\Omega$ $Z_B = 12\angle 30\,\Omega$ $Z_C = 10\angle 45\,\Omega$ [illegible] circuit [illegible] vector [illegible] line current [illegible] ~~neutral wire [illegible] current~~ 3ϕ load [illegible] power [illegible] V sequence CBA [illegible]





CBA

$E_{pnA} = 240\angle 0$

$E_{pnB} = 240\angle 120$

$E_{pnC} = 240\angle 240$

$$E_N = \frac{E_{pnA}Y_{AN} + E_{pnB}Y_{BN} + E_{pnC}Y_{CN}}{Y_{AN} + Y_{BN} + Y_{CN}}$$

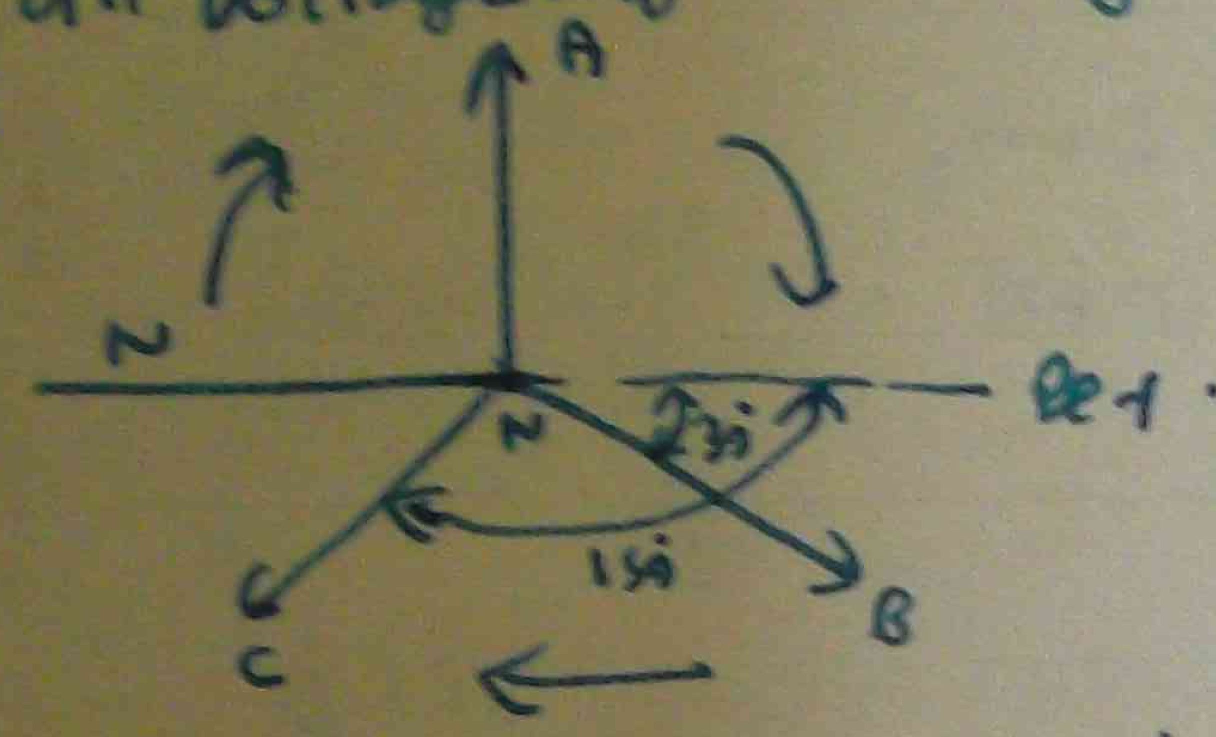
$$= \frac{240\angle 0 \times \frac{1}{12\angle 0} + \frac{240\angle 120}{12} \times \frac{1}{12\angle 30} + 240\angle 240 \times \frac{1}{10\angle 45}}{\frac{1}{12\angle 0} + \frac{1}{12\angle 30} + \frac{1}{10\angle 45}}$$

$$= \frac{20\angle 0 + 20\angle 90 + 24\angle 195}{.08333 + .08333\angle -30 + .1\angle -45}$$

50A 20A 60A

$= .15 + .0655 = .2155\Omega$

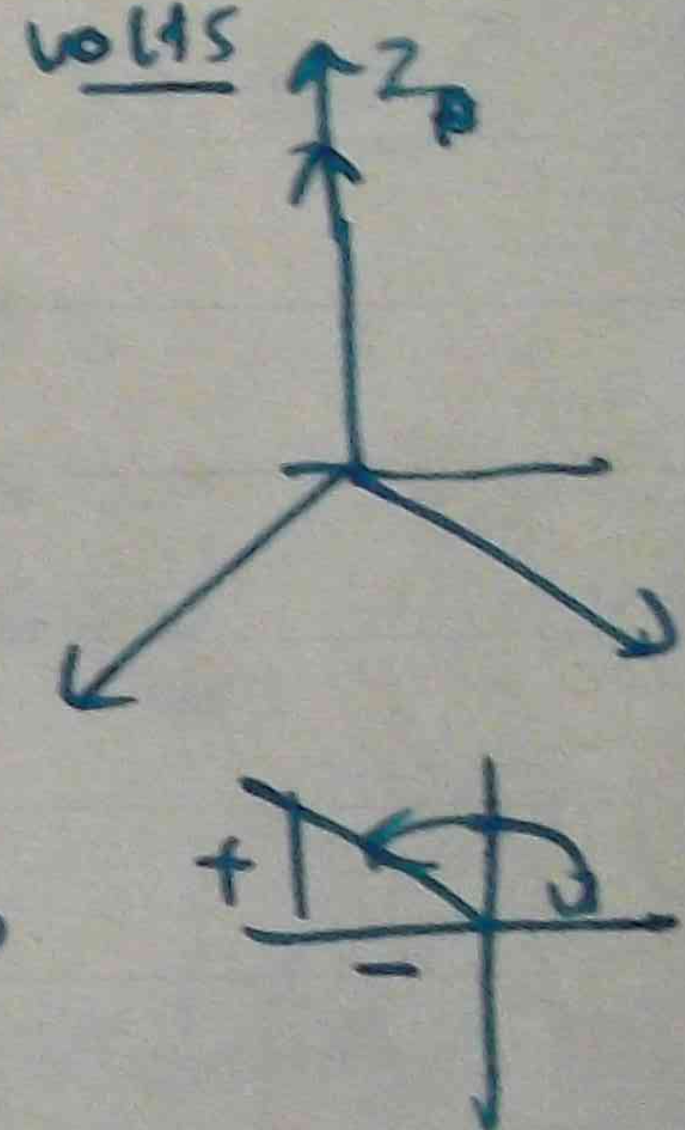
3φ 4wire 416V CBA supply [illegible] 4wires star load [illegible] $Z_A = 12\angle 0\,\Omega$ $Z_B = 12\angle 30°\,\Omega$ $Z_C = 10\angle 45°\,\Omega$ [illegible] circuits [illegible] vector [illegible] line current [illegible] 3φ load [illegible] power [illegible] voltage sequence CBA [illegible]



$$E_{AN} = \frac{416}{1.731}\angle -90° = 240\angle -90° \text{ volts}$$

$$E_{BN} = 240\angle 30° \text{ volts}$$

$$E_{CN} = 240\angle 150° \text{ volts}$$



$$I_{AN} = \frac{240\angle -90°}{12\angle 0} = 20\angle -90° \text{ amp}$$

$$I_B = \frac{240\angle 30°}{12\angle 30} = 20\angle 0 \text{ amp}$$

$$I_C = \frac{240\angle 150°}{10\angle 45} = 24\angle 105° \text{ amp}$$

$$I_N = 0 - J20 + 20 + J0 + 24(-\cos 75 + J\sin 75)$$
$$= 0 - J20 + 20 + J0 + 24(-.259 + J.967)$$
$$= 0 - J20 + 20 - 6.22 + J23.2$$
$$= 13.78 + J3.2 = 14.15\angle 13.08 \text{ amp}$$

$$P_{WT} = 20^2 \times 12 + 20^2 \times 12\cos 30 + 24^2 \times 10\cos 45$$
$$= 400 \times 12 + 400 \times 12 \times .866 + 576 \times 7.07$$
$$= 4800 + 4150 + 4075 = 13025 \text{ watts}$$

$$E_N = \frac{E_{phA} Y_{AN} + E_{phB} Y_{BN} + E_{phC} Y_{CN}}{Y_{AN} + Y_{BN} + Y_{CN}}$$

$$= \frac{20 + J0 + 0 + J20 + 24\cos 15 - J24\sin 15}{.08335 + .08335\cos 30 - J.08335\sin 30 + .1\cos 45 - J.1\sin 45}$$

$$= \frac{20 + J20 - 23.18 - J6.22}{.08335 + .072 - J.04175 + .0707 - J.0707}$$

$$= \frac{-3.18 + J13.78}{.22605 - J.11235} = \frac{14.15 \angle 180 - 77}{.2525 \angle -26.4} = 56.1 \angle 129.4$$

$$E_N = 56.1\,(-\cos 50.9 + J\sin 50.9)$$
$$= 56.1\,(-.63 + J.776)$$
$$= -35.35 + J43.5 \text{ volts}$$

$$E_{AN} = E_{PNA} - E_N$$
$$= 240 + J0 - (-35.35 + J43.5)$$
$$= 240 + J0 + 35.35 - J43.5$$
$$= 275.35 - J43.5 = 279 \angle -8.98 \text{ volts}$$

$$E_{BN} = 240(-\cos 60 + J\sin 60) + 35.35 - J43.5$$
$$= -120 + J208 + 35.35 - J43.5$$
$$= -84.65 + J164.5 = 185 \angle 180 - 62.8 \text{ volts}$$

$$E_{CN} = 240(-\cos 60 - J\sin 60) + 35.35 - J43.5$$
$$= -120 - J208 + 35.35 - J43.5$$
$$= -84.65 - J251.5 = 265 \angle 180 + 71.4$$
$$= 265 \angle 251.4 \text{ volts}$$

$$I_A = \frac{279 \angle -8.98}{12 \angle 0} = 23.25 \angle -8.98$$

$$I_A = 23.25(\cos 8.98 - J\sin 8.98) = 22.95 - J3.63 \text{ amp}$$

$$I_B = \frac{185 \angle 117.2}{12 \angle 30} = 15.4 \angle 87.2$$
$$= 15.4(\cos 87.2 + J\sin 87.2)$$
$$= .753 + J15.35 \text{ amp}$$

$$I_C = \frac{265 \angle 251.4}{10 \angle 45} = 26.5 \angle 206.4$$
$$= 26.5(-\cos 26.4 - J\sin 26.4)$$
$$= -23.7 - J11.8 \text{ amp}$$

$$I_N = I_A + I_B + I_C$$
$$= 22.95 - J3.63 + .75 + J15.35 - 23.7 - J11.8$$
$$= 0 + J.08 \text{ amp}$$
$$= .08 \angle -90^\circ \text{ amp}$$

or (0)

Total power $= (23.25)^2 \times 12 + (15.4)^2 \times 10.4 + (26.5)^2 \times 7.07$

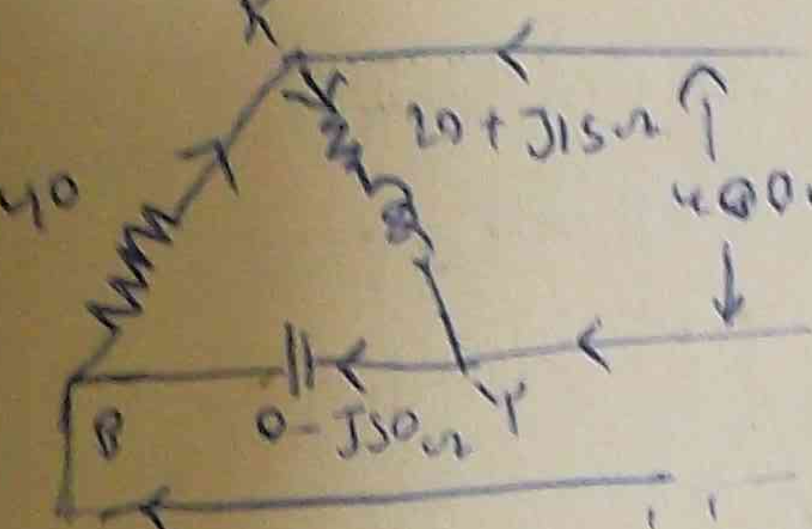
$= 541 \times 12 + 237 \times 10.4 + 702.5 \times 7.07$

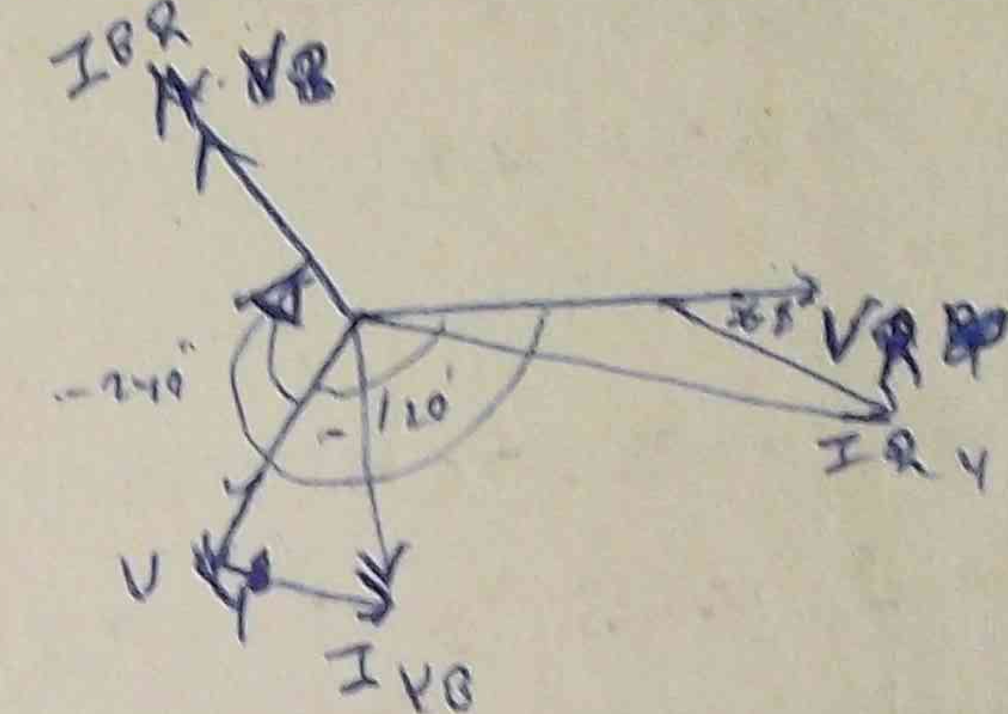
$= 6490 + 2465 + 4970$

$= 13925 \qquad 13.925\,kW$ //

⑥ 400 V 3φ symetrical supply [illegible] △ Load [illegible] $Z_{RY} = 20 + J15\,\Omega \quad Z_{YB} = 0 - J50\,\Omega$ $Z_{BR} = 40 + J0\,\Omega$ Phase sequence RYB [illegible] circuit [illegible] phasor [illegible] phase [illegible] Line current [illegible] power [illegible] 3φ Load [illegible] power [illegible]

Phase sequence RYB [illegible]





$I_{RY} = \dfrac{400}{20 + J15} = \dfrac{400}{25\,\angle 36.8} = 16\,\angle{-36.8}$ amp

$\therefore I_{RY} = 16(.8 - J.6) = 12.8 - J9.6$ amp

$I_{YB} = \dfrac{400}{50\,\angle{-90}} = 8\,\angle 90 = 0 + J8$ amp

$I_{BR} = \dfrac{400}{40\,\angle 0} = 10\,\angle 0 = 10 + J0$ amp

$\dot{I}_{BR} + \dot{I}_R = I_{RY} \quad \dot{I}_R = \dot{I}_{RY} - \dot{I}_{BR} = 12.8 - J9.6 - 10$

$= 2.8 - J9.6 = 10\,\angle{-73.7}$ amp

$\dot{I}_{RY} + \dot{I}_Y = \dot{I}_{YB}, \quad \dot{I}_Y = \dot{I}_{YB} - \dot{I}_{RY} = 0 + J8 - 12.8 + J9.6$

$= -12.8 + J17.6 = 22\,\angle 126$ amp

$\dot{I}_{YB} + \dot{I}_B = \dot{I}_{BR} \quad \dot{I}_B = \dot{I}_{BR} - \dot{I}_{YB} = 10 + J0 - (0 + J8)$

$= 10 - J8 = 12.8\,\angle{-38.7}$ amp

Total power $= 16^2 \times 20 + 8^2 \times 0 + 10^2 \times 40$

$= 5120 + 4000 = 9120\,watts = 9.12\,kW$

*

⑦ 3φ 400 V RYB supply [illegible] power [illegible] 400 V [illegible] Lighting 230 V [illegible] unbalanced lamp load [illegible] phase [illegible] 70, 84, 33A [illegible] neutral current [illegible] line current 200 A [illegible] pf 0.2 [illegible] motor [illegible] main line current [illegible] Neutral current [illegible] Load [illegible] Power [illegible]

KN 8

ရွှေပြည်စိုး တံဆိပ်

16J

KN 8

အမည်: Maung Kyaw Naing

ကျောင်း: G.T.I

အတန်း: 3EP(A)

ဘာသာ Hydraulics

ကိုးကားချက်စာအုပ် - Hydraulics by E.H. Lewitt

Maung Kyaw Naing
3EP(A)
Hydraulics
G.T.I

Hydraulics (ရေအကြောင်းပညာရပ်)

① Hydel power or Hydro electricity (due to potential energy of the water)
② Thermal power
 ① Disel ② steam turbines ③ Gas turbines

ရေအကြောင်းအရာကို ရေငြိမ်တွင် Hydrostatics ဟူ၍၎င်း၊ ရေစီးတွင် Hydro dynamics ဟူ၍၎င်း ခွဲခြား၏။ ရေသည် အင်္ဂလိပ်စကားလုံး Hydromamics ကို Engineer များ အသုံးချသော အခါ လက်တွေ့အသုံးပြုရသော ဂုဏ်သတ္တိဖြင့် ပြင်ဆင်သော ပညာကို Hydraulics ဟုခေါ်သည်။

မှတ်သားရန်အချက်များ

① ရေ၏အလေးချိန်သည် 62.4 lb/cu ft ဖြစ်သည်။
② 1 gallon = 10 lbs
 P = pressure = ဖိအားနှုန်း lb/in²

Fluid-

လွယ်လင့်တကူ စီးဆင်းနိုင်သော အရာဝတ္ထုကို fluid ဟုခေါ်သည်။

Properties of liquids
(အရည်၏ဂုဏ်သတ္တိများ)

① liquids are incompressible ၊ အရည်တို့ကို ဖိသော်လည်း ထုထည်ပြောင်းလဲခြင်း မရှိပေ ရေကိုပမာဏ အရည်တို့သည် မည်သို့ပင်ဖိသော်လည်း ပြောင်းလဲ သွားခြင်း မရှိ။ ထို့ကြောင့် ရေနှင့် အရည်တို့ကို ဖိသော်လည်း ပြောင်းလဲခြင်းမရှိသော အရာဝတ္ထု ဟု မှတ်ယူရသည်။
② ရေခိုးရေငွေ့နှင့် ဓါတ်ငွေ့များကို သည် အနည်းငယ်ဖိသော် လျော့ခြင်း ဖြင့် ၎င်းတို့၏ထု ထည်သေးငယ်ခြင်းသို့ သွားတတ်သည်။ ထို့ကြောင့် ရေခိုးရေငွေ့နှင့် ဓါတ်ငွေ့တို့ကို ဖိသော် ပြောင်းလဲနိုင်သော အရာဝတ္ထုများဟု မှတ်သားထားသည်။

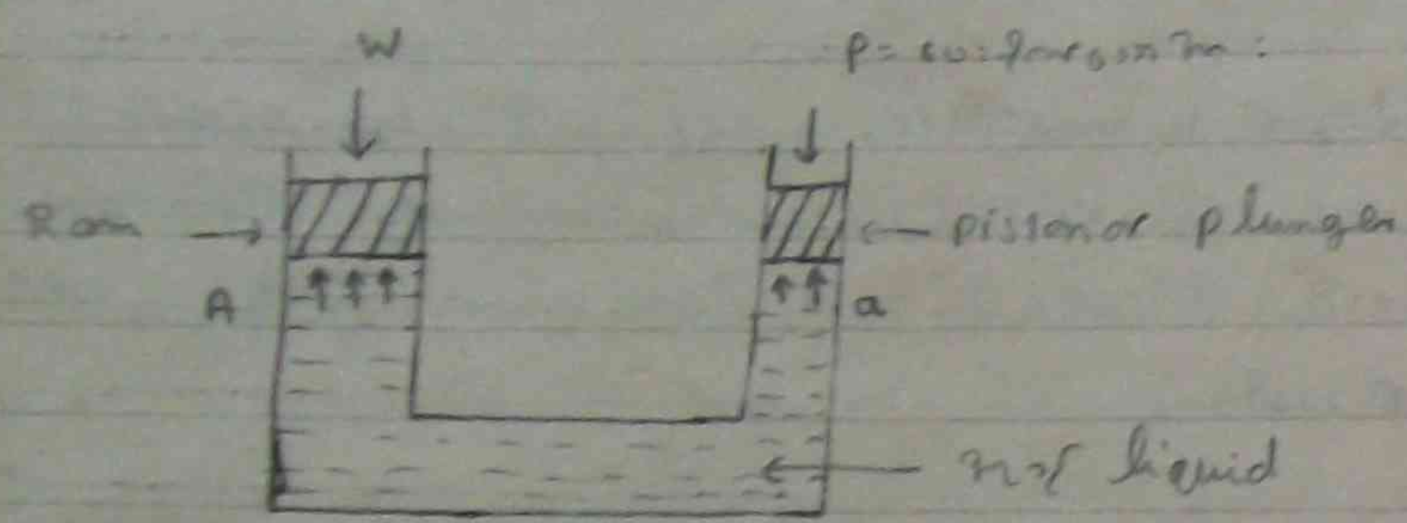
② Intensity of pressure in a liquid acts equally in all direction at any point.

[illegible]

$$P = \frac{F}{A} \quad lb/in^2 \qquad A: \text{area } (in^2)$$

Intensity of pressure $= \dfrac{\text{Normal force}}{\text{Area}}$ lb/in^2

Normal force = [illegible]



Hydraulic jack

piston [illegible] area $= a \ in^2$

Ram " " " $= A \ in^2$

$$P = \frac{W}{A} \ lb/in^2$$

$$P = \frac{p}{a} \ lb/in^2$$

$$\frac{W}{A} = \frac{p}{a}$$

$$p = W \times \frac{a}{A} \quad lbs$$

$$W = p \times \frac{A}{a} \quad lbs$$

Hydraulics jack [illegible]

[illegible] Hydraulics jack [illegible] $p = \dfrac{p}{a} = \dfrac{W}{A}$ lb/in^2 [illegible]

Prob: ①

Hydraulic jack [illegible] Ram [illegible] 7" [illegible] Piston [illegible] 1" [illegible] Ram [illegible] 1 ton [illegible] plunger [illegible]

$$A = \frac{\pi}{4} \times 7^2$$

$$a = \frac{\pi}{4} \times 1^2$$

$$p = w \times \frac{a}{A}$$

$$= 2240 \, lb \times \frac{\frac{\pi}{4} \times 1^2}{\frac{\pi}{4} \times 7^2}$$

$$= \frac{2240}{49} = 45.7 \ lb$$

Exam: no①

SP

Prob: ②

Hydraulic jack [illegible] Ram [illegible] 5" [illegible] piston [illegible] $\frac{1}{2}$" [illegible] Ram [illegible] 1 ton [illegible] plunger [illegible] Plunger [illegible] stroke [illegible] 10" [illegible] 1 ton [illegible] stroke [illegible] 1 ton [illegible] plunger [illegible]

$$\frac{W}{A} = \frac{p}{a}$$

$$\frac{2240}{\frac{\pi}{4}(5)^2} = \frac{p}{\frac{\pi}{4}\left(\frac{1}{2}\right)^2}$$

$$p = \frac{2240}{25} \times \frac{1}{4} = \frac{2240}{100} = 22.4 \ lb$$

let n = number of stroke

Ram [illegible] = plunger [illegible]

[illegible] $\times$ [illegible] = [illegible] $\times$ Stroke $\times$ n

[illegible]

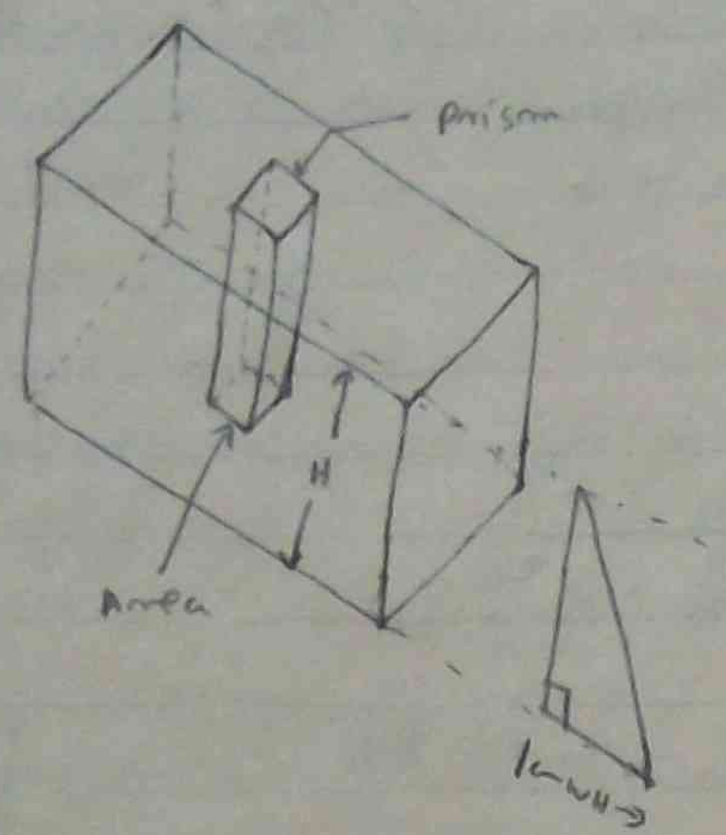
$$2240 \times 3 \times 12 = 22.4 \times 10'' \times n$$

$$n = \frac{2240 \times 3 \times 12}{22.4 \times 10} = 360$$

$$\therefore \text{HP required} = \frac{22.4 \times \frac{10}{12} \times 360}{12 \times 33000} = 0.017 \ HP$$

$\frac{lb/in^2}{lb/in^3}$

Pressure head of a liquid
([illegible])



Prism [illegible] $1 ft^2$ [illegible] area [illegible]
[illegible] = Prism[illegible] = [illegible] x [illegible]

$$= w\ lb/ft^3 \times ft^2 \times H\ ft$$
$$= wH\ lb$$

[illegible] 1 sq ft [illegible]
[illegible]

$$p\ lb/ft^2 = wH\ lb/ft^2$$

[illegible] H ft [illegible]
[illegible] 1 sq ft [illegible] area [illegible]
[illegible] area [illegible]
(Prism) [illegible]
[illegible] Prism [illegible] 1 sq ft x H ft [illegible] Prism
[illegible] wH lb [illegible]

Prism [illegible] area [illegible] 1 unit [illegible] (1 sq ft) [illegible]
1 unit area [illegible]
[illegible]

[illegible] $P = wH\ lb/\square''$

P = [illegible] $lb/\square''$

w = [illegible] $lb/cuft$

H = [illegible] (ft)

$\frac{lb/in^2}{lb/in^3}$

[illegible]
([illegible])
[illegible]

Prob (1)

7 miles [illegible]
[illegible] tons/$\square''$ [illegible] ([illegible] 64 lb/ft³)
([illegible] 62.5 lb/cuft)

$$P = wH \qquad H = \frac{P}{w}$$

$$= \frac{64 \times 7 \times 5280 \times 12}{2240 \times 12 \times 12 \times 12}$$

$$= \frac{448 \times 63360}{2240 \times 1728} = \frac{28400000}{3870000} = 7.33\ tons/\square''$$

SP

Prob (2)

Rectangular tank [illegible] 14' [illegible] 5' [illegible]
[illegible] 6' [illegible]
[illegible] lb/in² [illegible]
[illegible]

[illegible] $P = wH$

$$= \frac{62.5 \times 6 \times 12}{144 \times 12}$$

$$= \frac{375.0}{144} = 2.6\ lb/\square''$$

[illegible] = 6 x 14 = 84 sq ft

[illegible] = 6 x 5 = 30 sq ft

[illegible]

[illegible] = [illegible] x [illegible]

$$= \frac{0+P}{2} \times A$$

$$= \frac{0+2.6}{2} \times 12 \times 12 \times 84$$

$$= 15700\ lb$$

$$P = \frac{2.6 \times 12 \times 12 \times 30}{2} = 5620$$

Pb ①

[illegible] 76 cm [illegible] 13.6 [illegible] lb/in^2 [illegible] ft of water [illegible]

centimeter of water = $76 \times 13.6 = 1033$

$\therefore$ Inches of water = $\frac{1033}{2.54} = 407$

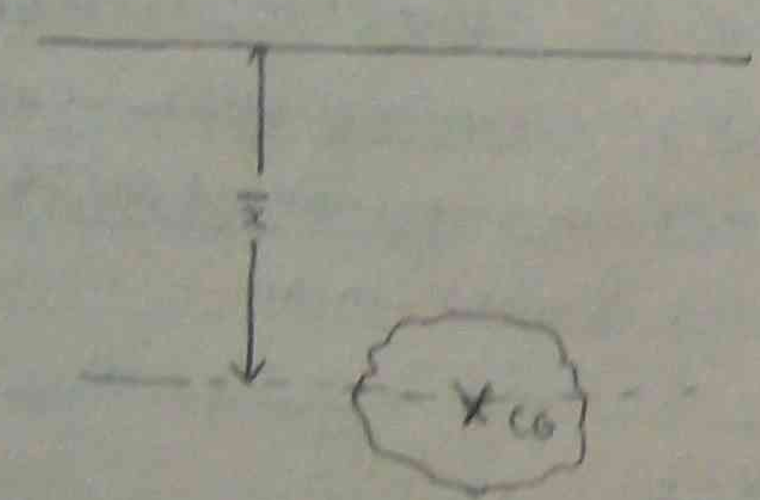
ft of water = $\frac{407}{12} = 33.92$

$lb/sq\,ft = wH = 62.4 \times 33.92 = 2117$

$\therefore lb/\square'' = \frac{2117}{12 \times 12} = 14.7\ lb/\square''$

Total Pressure on an immersed surface

[illegible] (plb)



$P = w a \bar{x}$ lbs

P = Total Pressure in lb

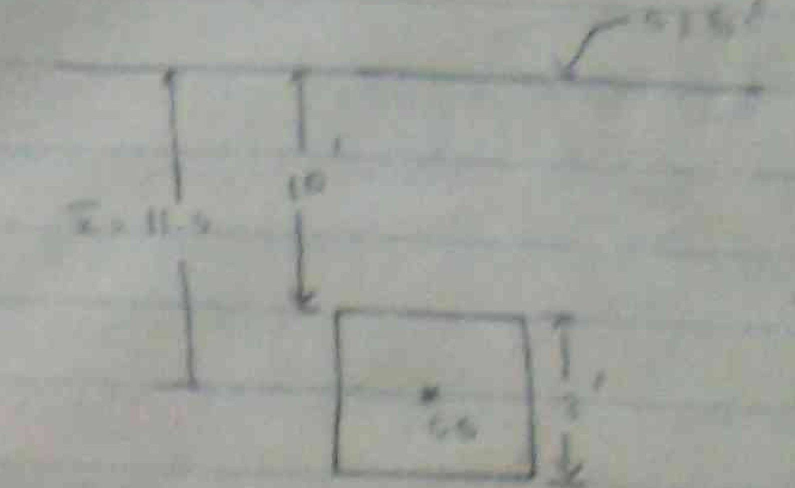
w = [illegible] $lb/cu\,ft$

A = [illegible] area ft^2

$\bar{x}$ = [illegible] ft

[illegible] area [illegible] centre gravity (CG) [illegible]

Prob: ① [illegible] 10 [illegible]



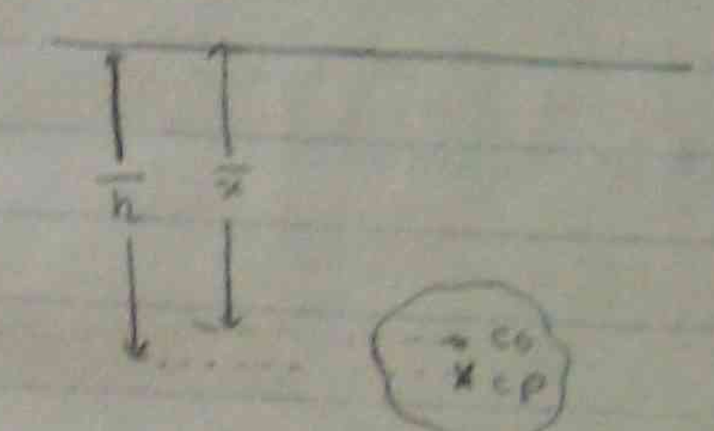
$\bar{x} = 10 + 1.5 = 11.5$

$w = 62.5$

$A = 3 \times 3 = 9$ sq ft

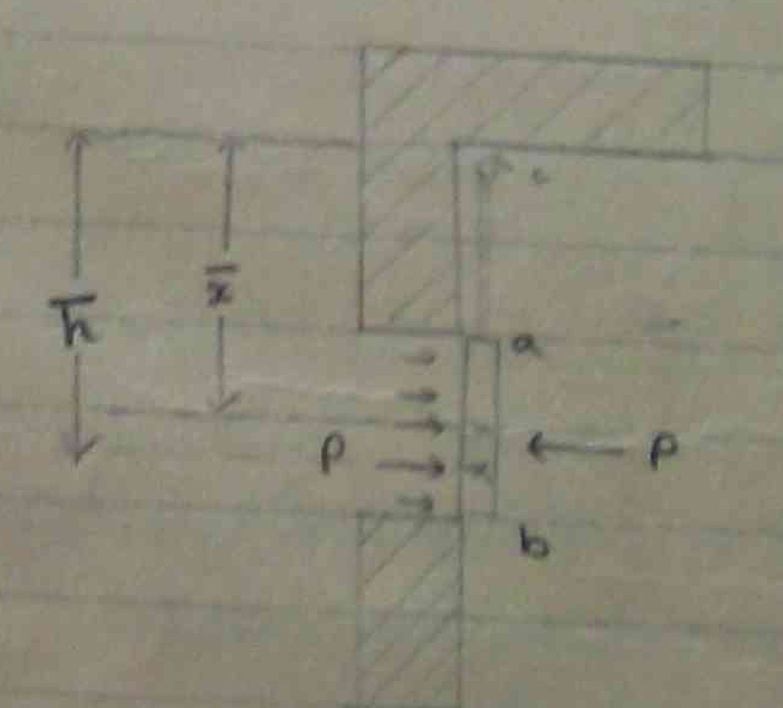
$P = w a \bar{x} = 62.5 \times 9 \times 11.5 = 62.5 \times 103.5 = 6470$ lb

Centre of Pressure (C.P)



[illegible] (Total pressure [illegible] centre of pressure [illegible] CG [illegible]

~~Prob~~ ②



[illegible] a b [illegible] P [illegible]

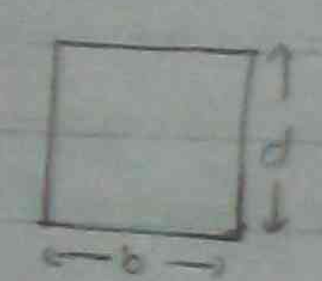
[illegible] central pressure [illegible] [illegible] [illegible] [illegible] central pressure [illegible] central gravity [illegible]

$$P = wa\bar{x}$$

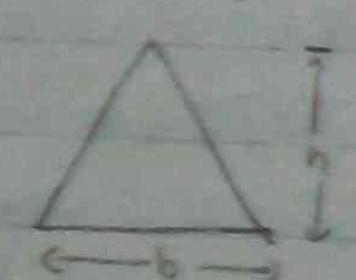
$$\bar{h} = \frac{I_o}{A\bar{x}}$$

I_o = moment of inertia about water surface

$$I_o = I_G + A\bar{x}^2$$



$$I_G = \frac{bd^3}{12} \quad in^4 \text{ or } ft^4$$



$$I_G = \frac{bh^3}{36} \quad in^4$$

$$I_G = \frac{\pi d^4}{64} \quad in^4$$

$$\bar{h} = \frac{I_G + A\bar{x}^2}{A\bar{x}} = \frac{I_G}{A\bar{x}} + \bar{x}$$

$\bar{h}$ = [illegible] ft

I_G = [illegible] moment of inertia

Prob ①

[illegible] 6' [illegible] 1 ft [illegible] total pressure [illegible] centre of pressure C.P [illegible]

Total Pressure = P

$$P = wa\bar{x} \qquad \bar{x} = 4$$

$$= 62.5 \times \frac{\pi \times 6^2}{4} \times (3+1)$$

$$= 62.5 \times \pi \times 9 \times 4$$

$$= 196.2 \times 36 = 7060 \text{ lb}$$

$$I_G = \frac{\pi d^4}{64} = \frac{22}{7} \times \frac{6^4}{64} = \frac{22}{7} \times \frac{36 \times 36}{64} = \frac{22 \times 1296}{448}$$

$$= \frac{28500}{448} = 63.6 \text{ ft}^4$$

$$A = \frac{22}{7 \times 4} \times 6^2 = 28.25 \text{ sq ft}$$

$$I_o = I_G + A\bar{x}^2$$

$$= 63.6 + 28.25 \times 16 = 515.6 \text{ ft}^4$$

$$\therefore \bar{h} = \frac{I_G}{A\bar{x}} = \frac{515.6}{28.25 \times 4} = 4.56'$$

Prob ②

Square [illegible] 6' [illegible] 6' [illegible]

$$\bar{x} = 6 + 3 = 9$$

Total pressure $= \cancel{62.5}\, wa\bar{x}$

$$= 62.5 \times 6 \times 6 \times 9$$

$$= 62.5 \times 324 = 20250 \text{ lb}$$

$$I_G = \frac{bd^3}{12} = \frac{6 \times 6^3}{12} = \frac{216}{2} = 108 \text{ ft}^4$$

$$A = 6 \times 6 = 6 \text{ ft}^2$$

$$\bar{x} = 9$$

$$\bar{h} = ?$$

$$\bar{h} = \frac{I_G}{A\bar{x}} + \bar{x}$$

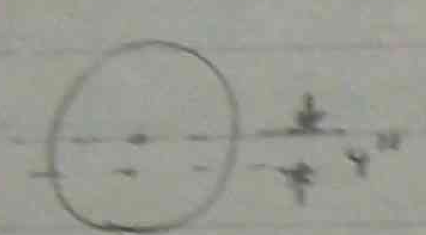
$$= \frac{108}{32 \times 9} + 9$$

$$= \frac{108}{324} + 9 = 9 + .33 = 9.3333$$

Prob ③ SP

[illegible]

[illegible]



$$\bar{h} = \frac{I_G}{A\bar{x}} + \bar{x}$$

$$\bar{h} - \bar{x} = \frac{4}{12} = \frac{1}{3}\,ft \quad \text{—— ①}$$

$$\bar{h} = \frac{\pi d^4}{64} \times \frac{4}{\pi d^2 \times \bar{x}} + \bar{x}$$

$$\bar{h} = \frac{36}{16 \times \bar{x}} + \bar{x} = \frac{9}{4\bar{x}} + \bar{x}$$

① [illegible] $\frac{9}{4\bar{x}} + \bar{x} - \bar{x} = \frac{1}{3}$

$$\frac{9}{4\bar{x}} = \frac{1}{3}$$

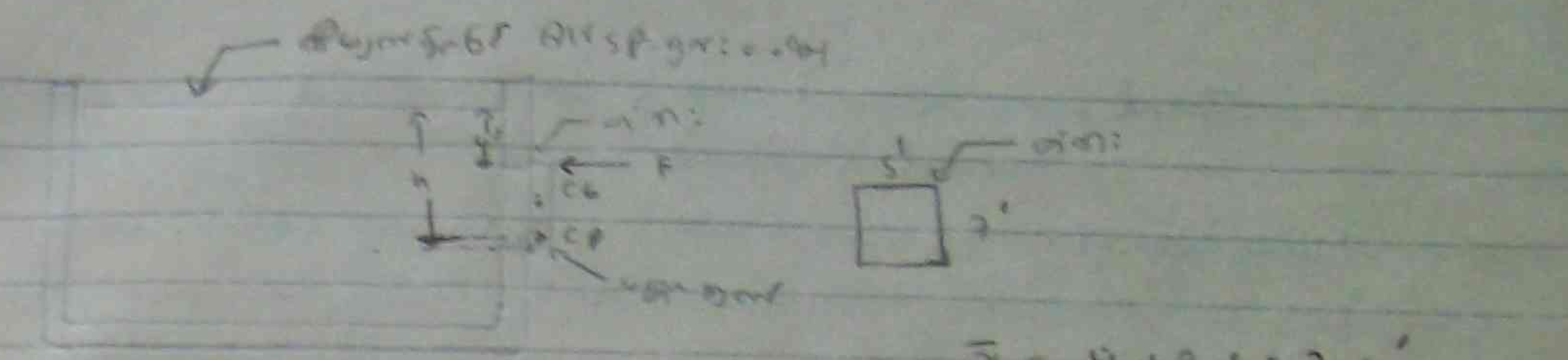
$$\therefore \bar{x} = \frac{27}{4} = 6.75\,ft$$

$$\therefore \bar{h} = 6.75 + \frac{1}{3} = 7.09'$$

SP

Prob: ④

[illegible]



$$\bar{x} = 4 + 3.5 = 7.5'$$

$$\bar{h} = \frac{I_G}{A\bar{x}} + \bar{x}$$

$$I_G = \frac{bd^3}{12} = \frac{5 \times 7^3}{12} = \frac{5 \times 7 \times 7 \times 7}{12} = \frac{35 \times 49}{12} = \frac{1715}{12}$$

$$I_G = 143\ ft^4$$

$$\bar{h} = \frac{143}{7 \times 5 \times 7.5} + 7.5$$

$$= \frac{143}{35 \times 7.5} + 7.5$$

$$= \frac{143}{262.5} + 7.5 = 7.5 + .545 = 8.045\ ft$$

$$P = w a \bar{x}$$

$$= .84 \times 62.5 \times 5 \times 7 \times 7.5$$

$$= 52.5 \times 35 \times 7.5$$

$$= 52.5 \times 262.5 = 13780 \#$$

[illegible] $= 4 + 7 - 8.045$

$$d_1 = 2.955\ ft$$

[illegible]

$$\therefore 137800 \times 2.955 = F \times 7$$

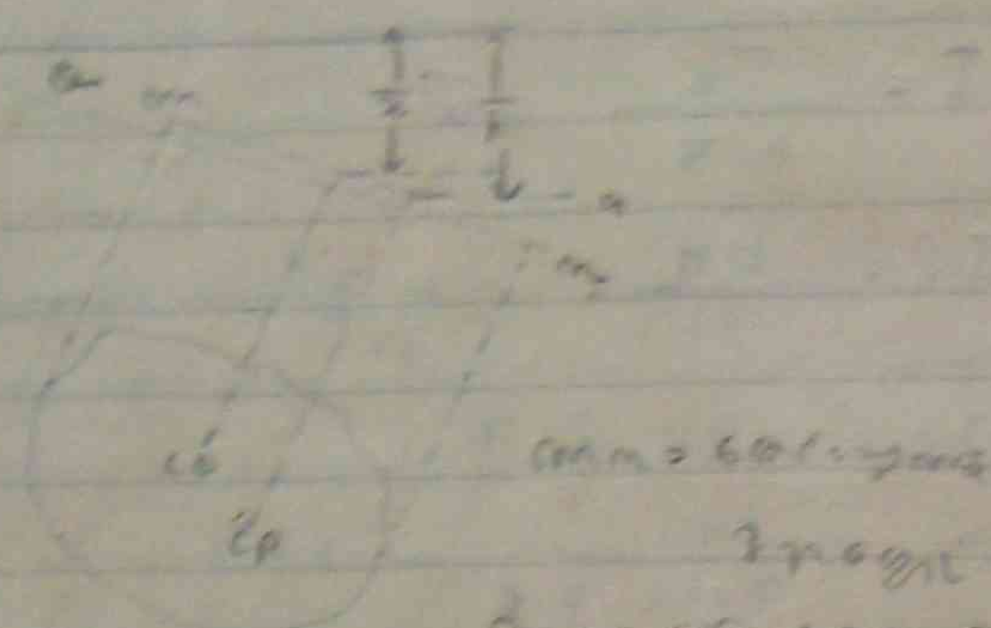
$$\therefore F = \frac{137800 \times 2.955}{7} = \frac{40700}{7} = \cancel{5800}\# \quad 5810 \#$$

Tota

Total pressure and centre of inclined Immersed surface

[illegible]

[illegible]



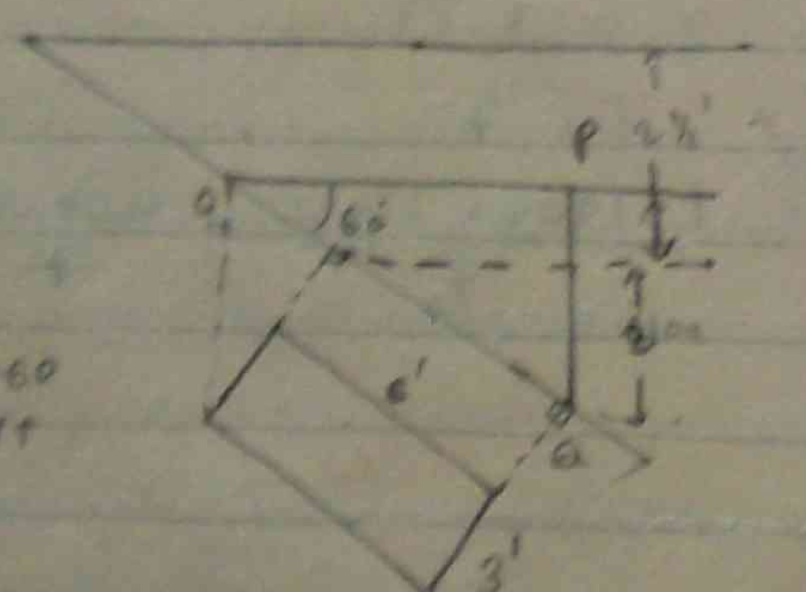
[illegible]

$P = wA\bar{x}$

$\bar{h} = \dfrac{I_G \sin^2\theta}{A\bar{x}} + \bar{x}$

Prob: 1

[illegible] Total Press[illegible] Centre of Pressure [illegible]



$\dfrac{PQ}{OQ} = \sin 60$

$PQ = 6 \times \sin 60$
$= 5.196\,ft$

$\theta = 60°$

$A = 6 \times 3 = 18\,sqft$

$\bar{x} = 2\tfrac{1}{2} + \dfrac{5.19}{2}$
$= 5.09\,ft$

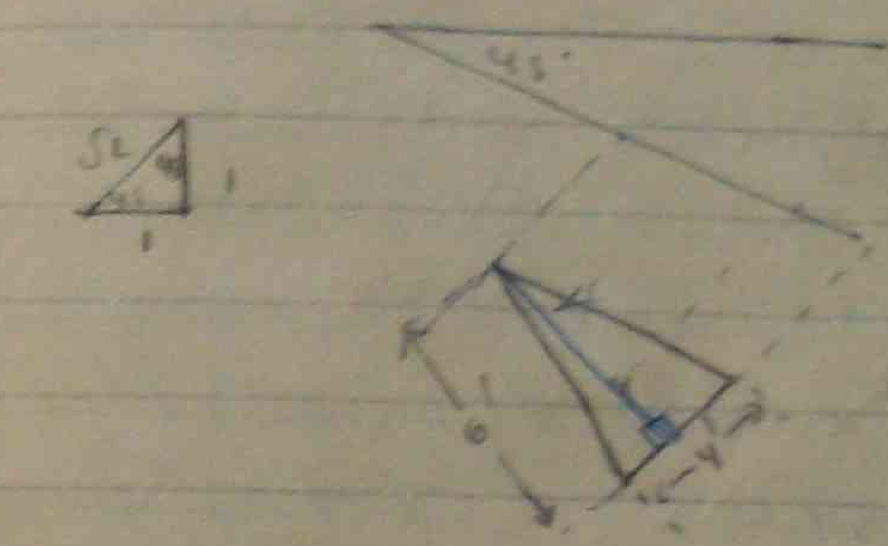
$\therefore P = wA\bar{x}$
$= 62.5 \times 18 \times 5.09$
$= 1125 \times 5.09$
$= 5735$

$I_G = \dfrac{bd^3}{12} = \dfrac{3 \times 6^3}{12} = 54\,ft^4$

$\bar{h} = \dfrac{54 \times 3/4}{18 \times 5.09} + 5.09$
$= \dfrac{162}{72 \times 5.09} + 5.09$
$= \dfrac{162}{366.5} + 5.09$
$= .443 + 5.09$
$= 5.532'$

Prob 2 [illegible]

[illegible] Total Pressure [illegible] Centre of Pressure [illegible]



[illegible] $= \tfrac{1}{3}h = \tfrac{1}{3} \times 6 = 2'$

$\bar{x} = 3 + \dfrac{4}{\sqrt{2}}$
$= 3 + 2.828$
$= 5.828'$

$P = wA\bar{x}$
$= 62.5 \times 12 \times 5.828$
$= 750 \times 5.828$
$= 4370\,lb$

$A = \tfrac{1}{2} \times 4 \times 6 = 12\,sqft$

$I_G = \dfrac{bd^3}{36} = \dfrac{4 \times 6^3}{36} = 4 \times 6 = 24\,ft^4$

$\bar{h} = \dfrac{I_G \sin^2\theta}{A\bar{x}} + \bar{x}$
$= \dfrac{24 \times (1/\sqrt{2})^2}{12 \times 5.83} + 5.83$
$= \dfrac{24 \times 1/2}{69.9} + 5.83$
$= \dfrac{12}{69.9} + 5.83$
$= .1718 + 5.83 = 6.0018'$

Prob (3) [illegible] Total pressure [illegible] centre of pressure [illegible]

$\sin\theta = \frac{3}{5} = .6$

$\theta = 36.8$

$x = 2.5 \sin 36.8$

$= 2.5 \times .6$

$= 1.5$

$\bar{x} = 3 + 1.5 = 4.5'$

$\text{Total} = wa\bar{x}$

$= 62.5 \times \frac{\pi}{4} \times d^2 \times 4.5$

$= 62.5 \times .7854 \times .75 \times 4.5$

$= 5520 \text{ lb}$

$I_G = \frac{\pi d^4}{64}$

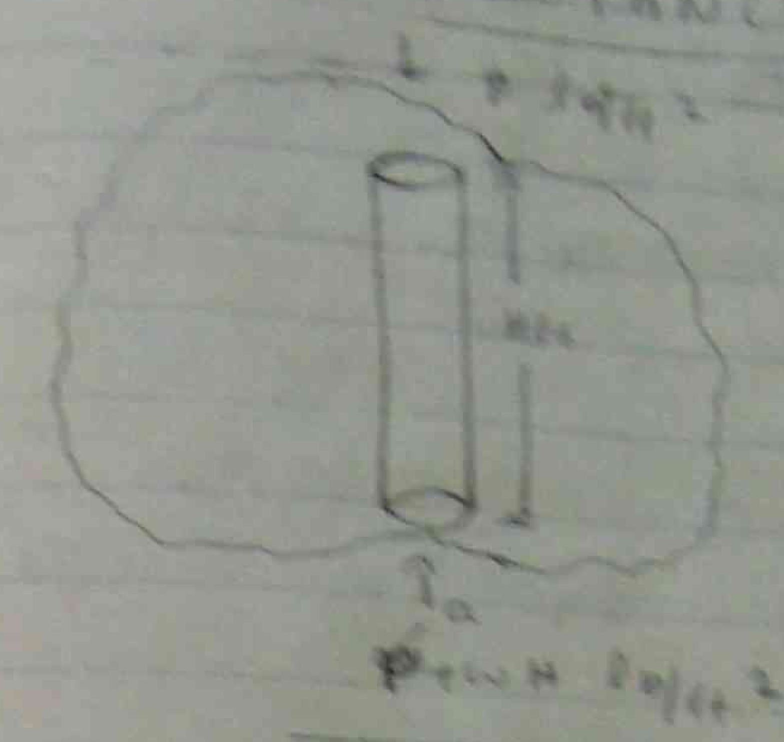
$\bar{h} = \frac{\pi \times 3 \times 6 \times 6 \times 5}{64 \times 4.5} \times \frac{3}{5} \times \frac{3}{5} \times \frac{4}{\pi} \times \frac{1}{5} \times \frac{1}{5} + 4.5$

$= \frac{36}{64 \times 4.5} + 4.5$

$= \frac{36}{288} + 4.5$

$= .125 + 4.5 = 4.625'$

BUOYANCY



[illegible] Buoyancy force [illegible]

[illegible] Buoyancy force [illegible]

[illegible] cylinder [illegible] area a [illegible] cylinder [illegible] $p \text{ lb/ft}^2$ [illegible] $p + wH \text{ lb/ft}^2$ [illegible]

$p \times a$ = cylinder [illegible]

$(p + wH)a$ = cylinder [illegible]

cylinder [illegible] $= (p + wH) \times a - pa$

[illegible] $= wH \text{ lbs}$

[illegible] = Buoyancy ([illegible])

Buoyancy force = $F_b = wH \times a$ lb

H = cylinder [illegible] = V cuft

$\therefore F_y = wHa = wV$

$\therefore$ [illegible]

Prob. ①

[illegible] 4000 cuft [illegible]

[illegible] 64 lb/cuft [illegible]

[illegible]

[illegible] : 4000 cuft

" " [illegible] = 64 lb/cuft

" [illegible] = 4000×64 = $F = wV$

= 256000 lbs or 114.2 tons

[illegible]

$F = 256000$

$w = 61.5$ lb/cuft

$v = ?$

$F = wV$

$\therefore V = \frac{F}{w} = \frac{256000}{61.5} = 4100$ cuft

Prob ②

[illegible] 60000 [illegible]

weight = 60000 tons

$F = 60000 \times 2240$ lbs

Vol: $= \frac{60000 \times 2240}{64}$

$= \frac{134400000}{64} = 2100000$ ft^3

Prob ③.

A ship has a displacement of 2200 tons in sea water. Find the vol: of the ship below the water line (1 ft^3 of sea water 64 lb)

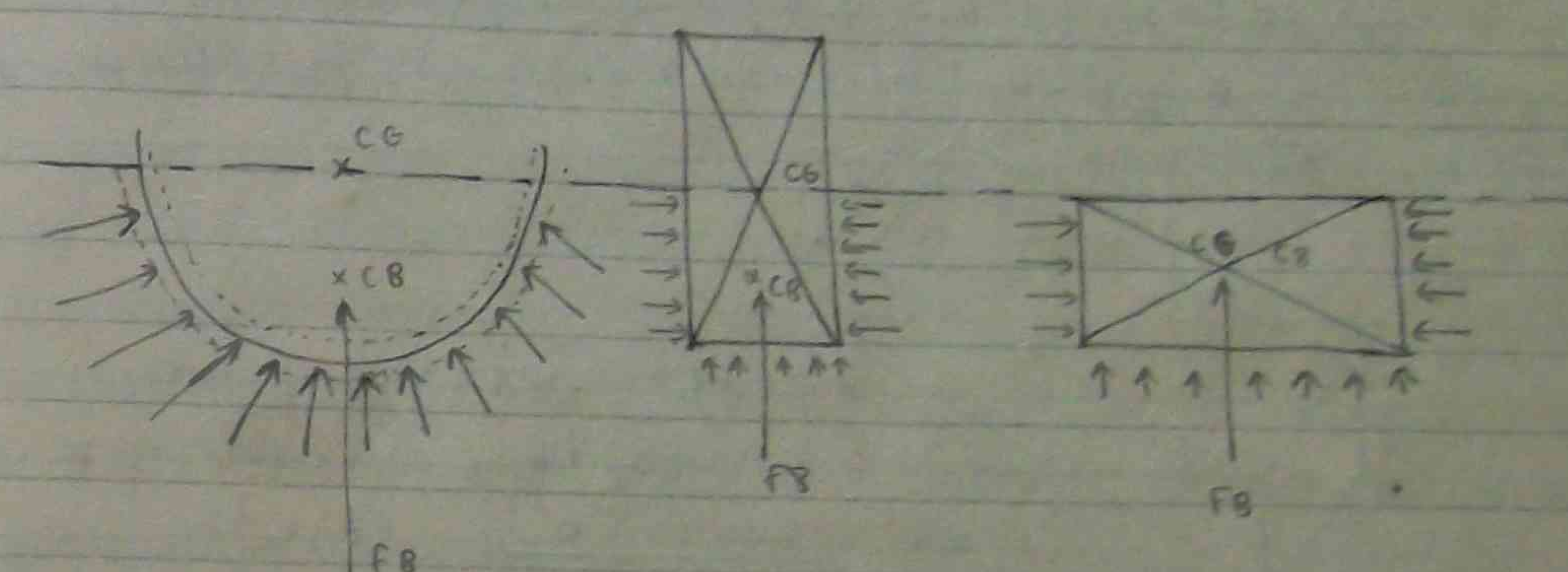
vol: = 2200 tons

$= 2200 \times 2240$ lbs $= w.V$

displacement or $v = \frac{F}{w} = \frac{2200 \times 2240}{64} = \frac{4928000}{64} = 77000$ ft^3

Centre of Buoyancy [C.B]

[illegible] [Buoyancy force] [illegible]



[illegible] central Buoyancy [illegible]

[illegible]

[illegible] central Buoyancy [illegible]

Prob: ① [illegible] 12' [illegible] 4' [illegible] 6' [illegible]

12' [illegible] 4' [illegible]

[illegible] 40 lb/cuft [illegible]

[illegible] central Buoyancy [illegible]

[illegible] = 40 lb/cu ft

[illegible] = 12 × 4 × 6 cu ft

[illegible] = 40 × 12 × 4 × 6 lbs

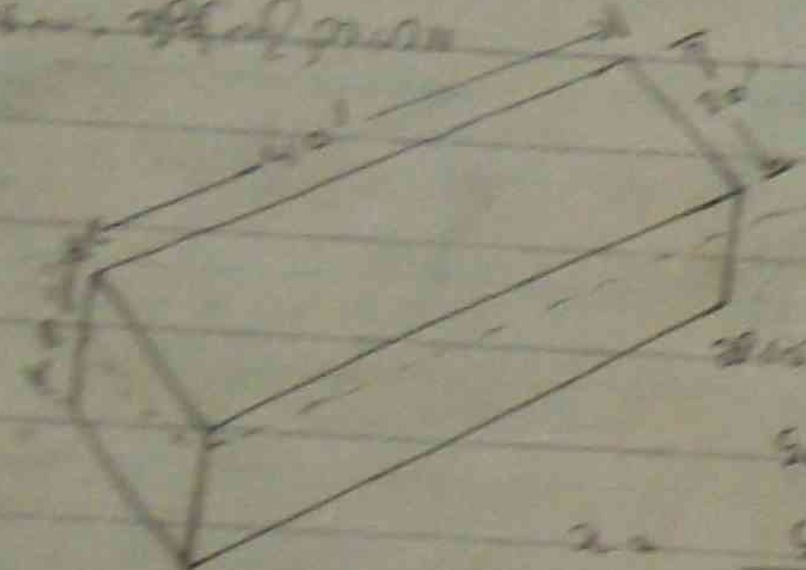
[illegible] = 62.5 lb/ft³

[illegible] = $\frac{40 \times 12 \times 6 \times 4}{62.5}$ = 184.5 ft³

[illegible] = $\frac{184.5}{4 \times 12}$ = 3.84 ft

4 Contract [illegible] = $\frac{3.84}{2}$ = 1.92 ft

Prob 2 [illegible] 40' [illegible] 20' [illegible] 8' [illegible]
[illegible] 50 tons [illegible]
[illegible]
[illegible]



[illegible]

50 × 2240 lb = 62.5 × 40 × 20 × x

x = $\frac{50 \times 2240}{62.5 \times 800}$ ft

= $\frac{112000}{50000}$ = 2.22 ft

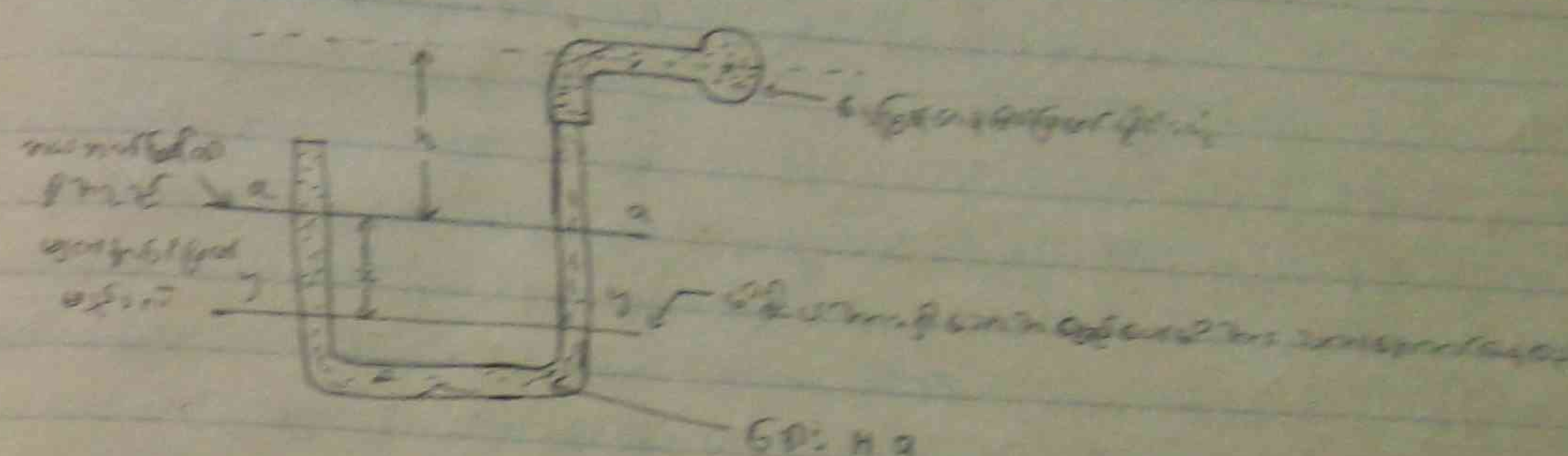
[illegible] = $\frac{62.4 \times 40 \times 20 \times \frac{8}{12}}{2240}$

= $\frac{62.4 \times 6400}{26880}$ = $\frac{4000}{269}$ = 14.7 tons

Pressure gauges

[illegible]

1 U Tube



[illegible]
[illegible] U tube [illegible] h [illegible] inches of water [illegible]
S [illegible] U Tube [illegible]
[illegible] U Tube [illegible]
[illegible]
[illegible] U tube [illegible]
[illegible]
[illegible] U tube [illegible]
[illegible]
[illegible]
[illegible]

[illegible] U tube [illegible]
[illegible]
U tube [illegible]
[illegible]

[illegible]
[illegible]

[illegible]

(1) Tube [illegible] :—

[illegible] = x inches of Hg

= x × S inches of water —— 1

U Tube [illegible] = h + h₁ + x inches of water

[illegible]

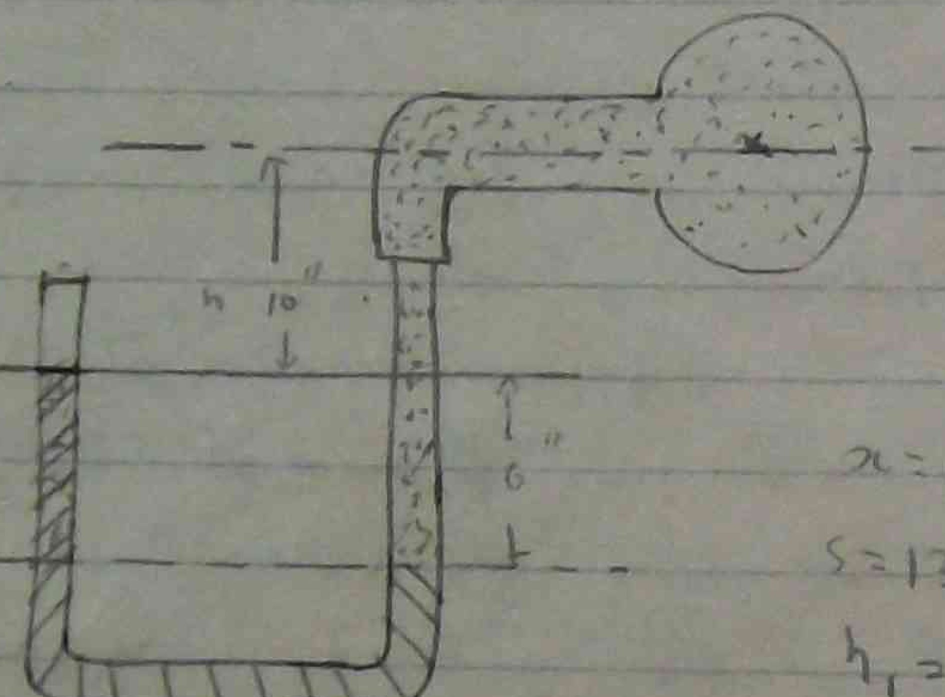
$$\textcircled{I} = \textcircled{II}$$

$$x s = h + h_1 + x$$

$$h = xs - x - h_1$$

$$h = x(s-1) - h_1 \quad \text{inches of water}$$

Prob ① [illegible] rubber pipe [illegible] U Tube [illegible] U tube [illegible] 10" [illegible] 6" [illegible] inches of water [illegible]



$x = 6''$

$S = 13.6$

$h_1 = 10''$

$$6 \times 13.6 = 6 + 10 + h_1$$

$$h = x(s-1) - h_1$$

$$= 6(13.6-1) - 10$$

$$\therefore h = 6 \times 12.6 - 10$$

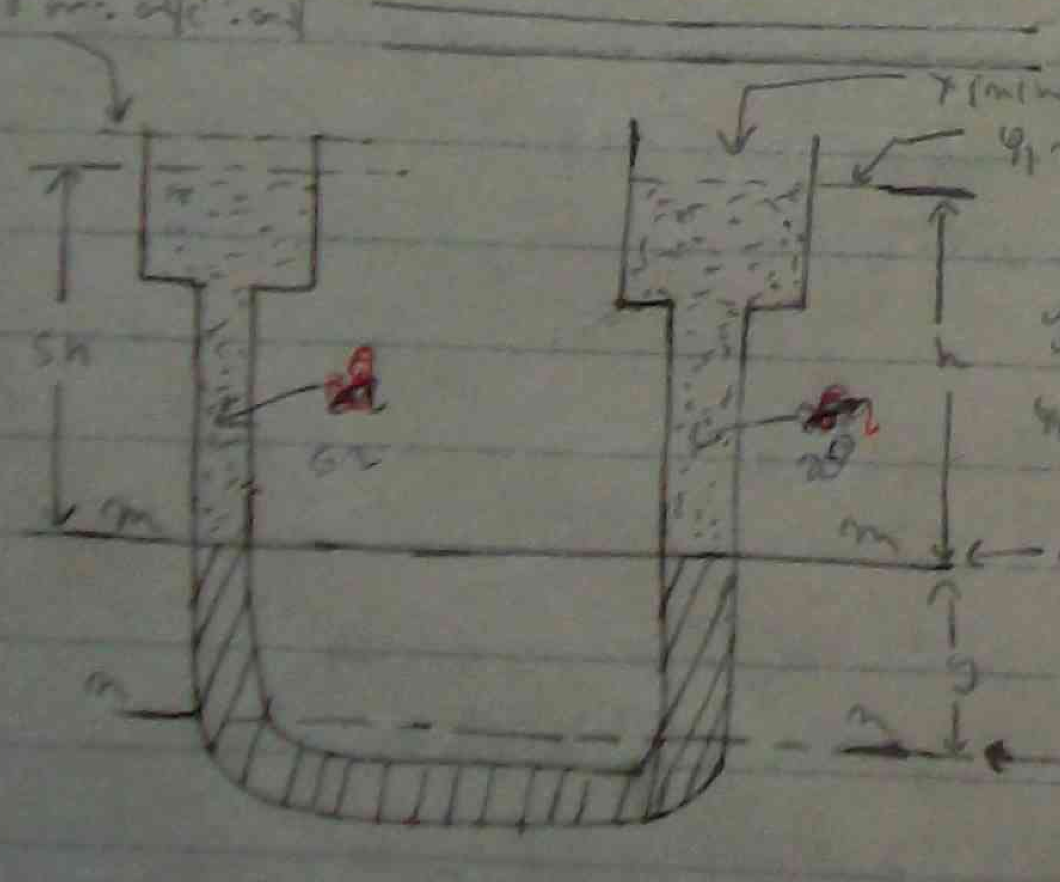
$$= 65.6 \text{ inches of water}$$

Tube [illegible]

① $\rho_1 h_1 + \rho_2 h_2 = \rho_3 h_3 + \text{Pr.head}$

② [illegible]

Differential Gauge



$y \frac{a}{A}$

A = [illegible] area a = [illegible] area

s = [illegible]

[illegible] pressure gauge [illegible] U Tube [illegible] area [illegible] pressure gauge [illegible] differential gauge [illegible]

[illegible] gauge [illegible] U tube [illegible] h [illegible]

[illegible] 100 [illegible] 100 [illegible]

[illegible] h inches of water [illegible]

U Tube [illegible] $y \times \frac{a}{A}$ [illegible] $y \times \frac{a}{A}$ [illegible] U tube [illegible]

U Tube [illegible] :—

[illegible] $= (y + sh + y\frac{a}{A})$ inches of water

U Tube [illegible] :—

[illegible] $= (y + h - y \times \frac{a}{A})$ inches of oil + x inches of water

$$(y + sh + y\tfrac{a}{A}) = (y + h - y\tfrac{a}{A}) S + x \qquad S = \frac{s_2}{s_1}$$

[illegible] -

$$y + sh + y\frac{a}{A} = (y + h - y\frac{a}{A})s + x \text{ inches of water}$$

$$y + sh + y\frac{a}{A} = sy + sh - sy\frac{a}{A} + x$$

$$x = y - sy + y\frac{a}{A} + sy\frac{a}{A}$$

$$= y(1-s) + y\frac{a}{A}(1+s)$$

$$x = y\left[(1-s) + \frac{a}{A}(1+s)\right]$$

Prob: Differential gauge [illegible] 0.25 sq in [illegible] 1 sq in [illegible] .95 [illegible] .9 [illegible] 1 in of water [illegible]

[illegible] = 0.25 sq in

[illegible] = 1 sq in

[illegible] .95

[illegible]

[illegible] .9

[illegible]

[illegible] 1 in of water

U-Tube [illegible]

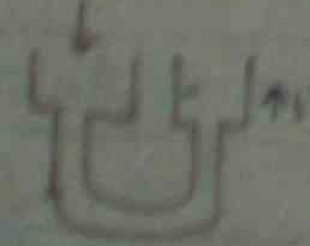
$$F_1 = (sh - y + y\frac{a}{A})s_1 \text{ inches of white liquid}$$

U-Tube [illegible]

$$F_2 = (h - y + y\frac{a}{A})s_2 \text{ inches of red liquid} + 1 \text{ in of water}$$

[illegible]

$$\left(\frac{.95}{.9}h - y + y\frac{.025}{1}\right).9 = \left(h - y + y\frac{.025}{1}\right).95 + 1 \text{ in of water}$$



from which $y = 20.4''$

$$F_1 = F_2 + x'' \text{ of water}$$

$$(Sh - y + y\tfrac{a}{A})s_2 = (h - y + y\tfrac{a}{A})s_1 + x'' \text{ of water}$$

$S =$ [illegible]

$$\left(\frac{S_2}{S_1}y - y + y\frac{a}{A}\right)S_1 = \left(h - y + y\frac{a}{A}\right)S_2 + x$$

[illegible]

Conditions of equilibrium of a floating body

[illegible]

1. Stable condition - [illegible]
2. Neutral condition - [illegible]
3. Unstable condition - [illegible]

* [illegible] stable condition [illegible]

(1) Stable condition

[illegible] Stable [illegible]

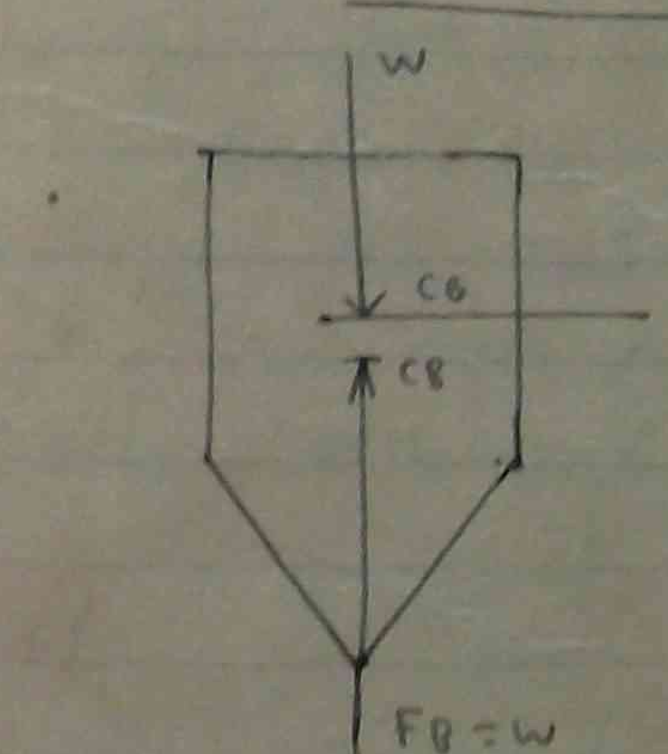
(2) Neutral condition

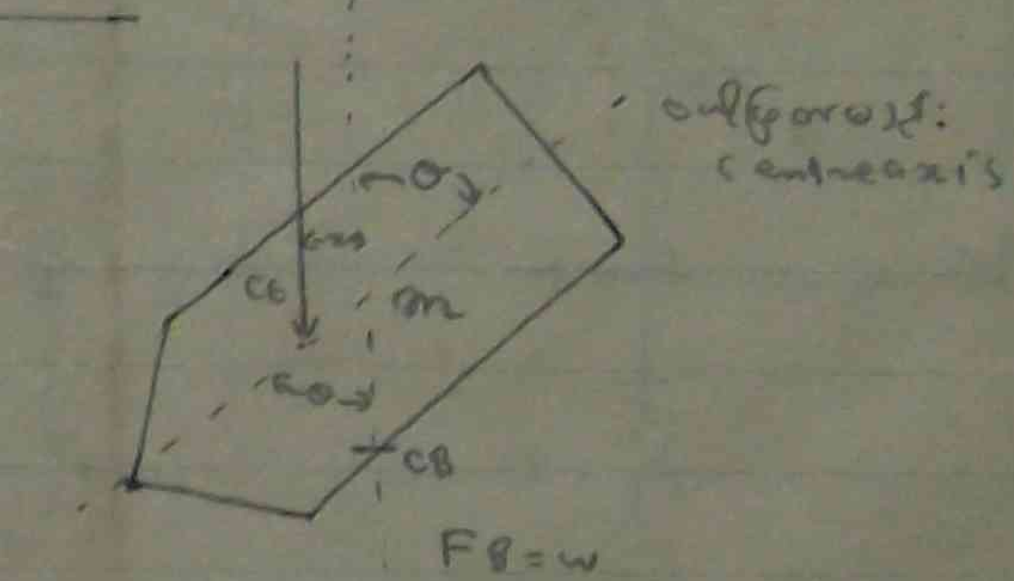
[illegible] Neutral [illegible]

(3) Unstable condition

[illegible] Unstable [illegible]

META CENTRE





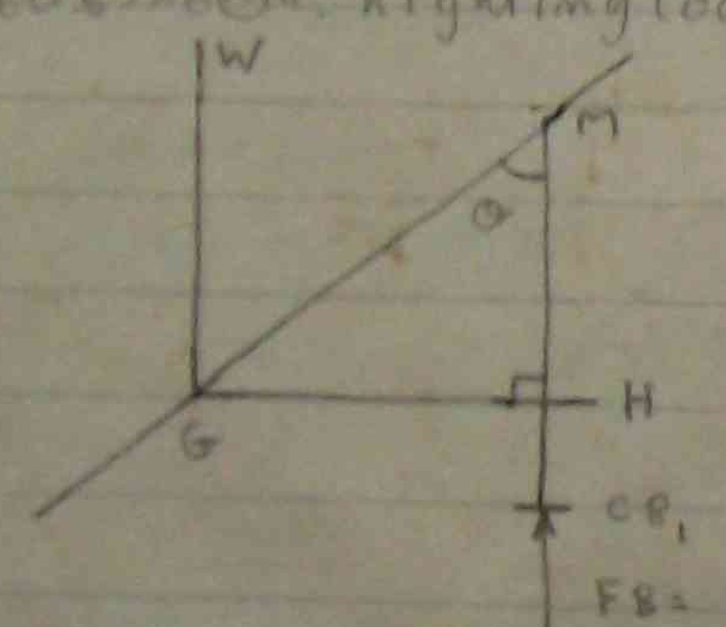
[illegible] Centre of Buoyancy [illegible] (meta centre) [illegible]

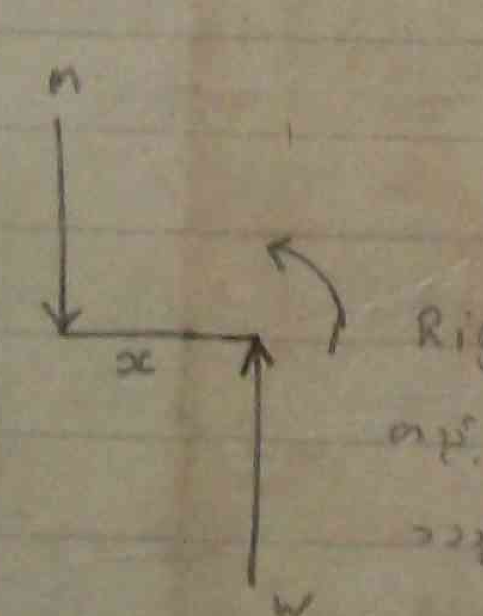
[illegible]

အလေးချိန်မှသည် central gravity CG တွင် သက်ရောက်နေသည်။ Buoyancy force FB သည် Central Buoyancy CB မှ သက်ရောက်နေသည်။ ရေယာဉ်… သည် … ညီမျှနေသောကြောင့် … ဖြစ်သည်။

အကယ်၍ ရေယာဉ်ကို θ စောင်းပေးလိုက်လျှင် ရေယာဉ်သည် … meta centre အမှတ် … မရှိပေ။

ရေယာဉ်၏ CG … Central Buoyancy အမှတ်အသစ်ကို CB1 ဟုသတ်မှတ်သည်။ CB1 တွင် F_B သက်ရောက်နေပြီး CG အမှတ်တွင် အလေး W သက်ရောက်နေပါ … x ရှိနေသောကြောင့် ရေယာဉ်ပေါ်တွင် couple Wx သည် ဖြစ်ပေါ်သက်ရောက်နေသည်။ couple သည် ရေယာဉ်ကို မူလအနေအထားသို့ ပြန်လည်ရောက်ရှိစေသောကြောင့် Righting couple ဟုခေါ်သည်။





Triangle MGH တွင် $\sin\theta = \frac{x}{MG}$

$\therefore x = MG\sin\theta$

MG = metric Height

Righting Couple = Wx

$= W\,MG\sin\theta$

Righting couple = $W\,MG\tan\theta$ [angle ငယ်လျှင် $\sin\theta = \tan\theta$]

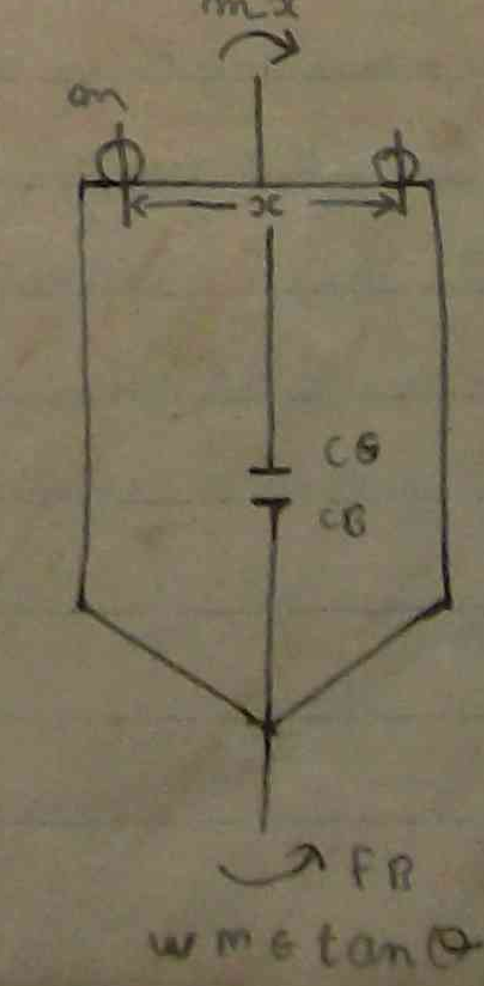
ရေယာဉ်ကို angle θ စောင်းပေးလိုက်သောအခါ ရေယာဉ်၏ meta centre အမှတ် M သည် CG အမှတ်၏ အထက်တွင် တည်ရှိနေသောအခါ ရေယာဉ်သည် … စောင်းသွားစဉ် Righting couple ဖြစ်ပေါ်သက်ရောက်… မူလ … ဖြစ်သည်။ ထို့ကြောင့် meta centre အမှတ်သည် CG အထက်တွင်ရှိနေသောအခါ ရေယာဉ်သည် stable ဖြစ်သည်ဟုခေါ်သည်။

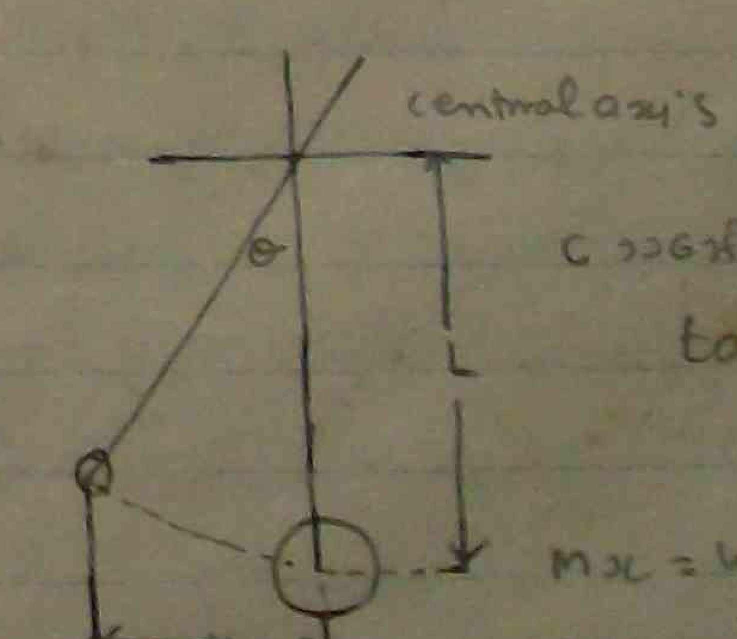
meta centre အမှတ် M သည် ရေယာဉ် (သို့မဟုတ်) သင်္ဘော၏ CG နှင့် တထပ်တည်းတွင်ရှိသောအခါ ရေယာဉ် (သို့မဟုတ်) သင်္ဘောကို အနည်းငယ် စောင်းပေးလိုက်ပါက စောင်းသွားစဉ် မည်သည့် couple မှ ဖြစ်ပေါ်သက်ရောက်ခြင်း မရှိခြင်းကြောင့် ရေယာဉ် (သို့မဟုတ်) သင်္ဘောသည် စောင်းပေးလိုက်သော အနေအထားအသစ်တွင် ရပ်တည်နေလိမ့်မည်။ မူလအနေအထားသို့ … စောင်းသွားခြင်း မရှိသဖြင့် ဤအနေအထားကို neutral ဖြစ်သည်ဟုခေါ်သည်။

အကယ်၍ meta centre အမှတ် M သည် ရေယာဉ် (သို့မဟုတ်) သင်္ဘော၏ CG အမှတ်အောက်တွင်ရှိနေပါက ရေယာဉ် (သို့မဟုတ်) သင်္ဘောကို အနည်းငယ် စောင်းပေးလိုက်သောအခါ စောင်းသွားစဉ် ဖြစ်ပေါ်သက်ရောက်လာသော couple သည် ဆက်လက်၍ စောင်းမှောက်သွားစေရန် ဖြစ်ပေါ်ပေးသောကြောင့် ရေယာဉ် (သို့မဟုတ်) သင်္ဘောသည် စောင်းသောဘက်သို့ ဆက်လက်၍ စောင်းမှောက်သွားမည်ဖြစ်၍ ဤအနေအထားကို unstable ဖြစ်သည်ဟုခေါ်သည်။

ရေယာဉ့် သင်္ဘောများကို တည်ငြိမ်… stable ဖြစ်စေရန် meta centre အမှတ်ကို CG ၏ အထက်တွင် … အမြင့် … သတ်မှတ်ပေးရသည်။ သင်္ဘောများ၏ meta central height မှာ … 1' အထက်တွင်ရှိရသည်။

meta Centric Height (MG) ကိုတိုင်းတာခြင်း





C …

$\tan\theta = \frac{y}{L}$

$mx = W\,MG\tan\theta$

$MG = \frac{mx}{W\tan\theta}$

$\therefore MG = \frac{mx \times L}{W y}$ [$\because \tan\theta = \frac{y}{L}$]

[illegible] meta centric height (MG) [illegible]

[illegible]

Prob: ①

[illegible] 2000 tons [illegible] 15 tons [illegible] 30 ft [illegible] 1:30 [illegible] meta centric height [illegible]

[illegible] $W = 2000\,tons \quad m = 15\,tons$

$x = 30\,ft \quad \tan\theta = \frac{1}{30}$

$$MG = \frac{mx}{W\tan\theta}$$

$$= \frac{15 \times 30}{2000 \times \frac{1}{30}}$$

$$= \frac{15 \times 30 \times 30}{2000} = 4.5\ ft$$

Prob ②

1500 tons [illegible] 12 tons [illegible] 24 ft [illegible] 10 ft [illegible] 4.5" [illegible] meta centric height [illegible]

$W = 1500\,tons \quad L = 10\,ft$

$m = 12\,ton \quad y = 4.5'' = \frac{4.5}{12}\,ft$

$x = 24\,ft \quad MG = ?$

$$MG = \frac{m\,x\,L}{W\,y}$$

$$= \frac{12 \times 24 \times 10}{1500 \times \frac{4.5}{12}}$$

$$= \frac{12 \times 24 \times 10 \times 12}{1500 \times 4.5}$$

$$= \frac{432 \times 120}{6750} = \frac{51840}{6750} = 7.67\ ft$$

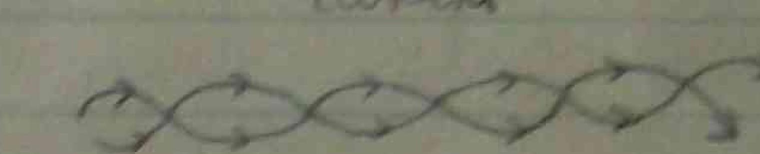
HYDRO DYNAMICS

([illegible])

Flow of liquid ([illegible])

laminar flow or parallel flow

Turbulent flow, Eddy or cross current



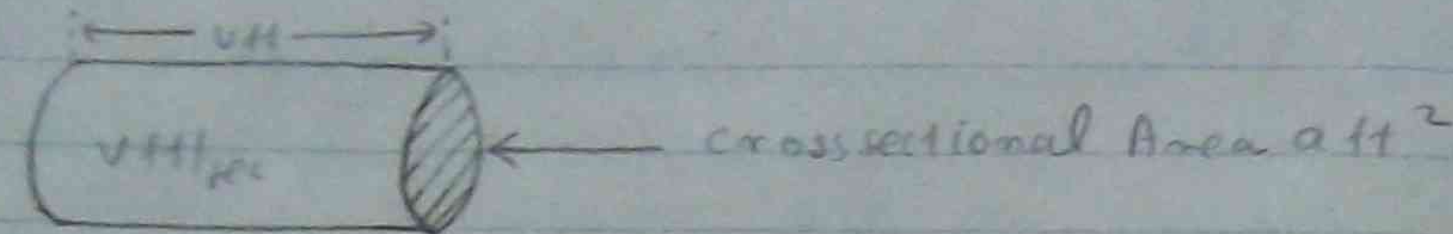
[illegible] velocity of flow [illegible] molecules [illegible]

laminar flow [illegible] parallel flow [illegible] flow [illegible] molecules [illegible]

[illegible] Turbulent flow [illegible] flow [illegible] molecules [illegible] Turbulent flow [illegible]

laminar flow [illegible] Turbulent flow [illegible] critical velocity [illegible]

Rate of flow [$Q\ ft^3/sec$] [illegible]



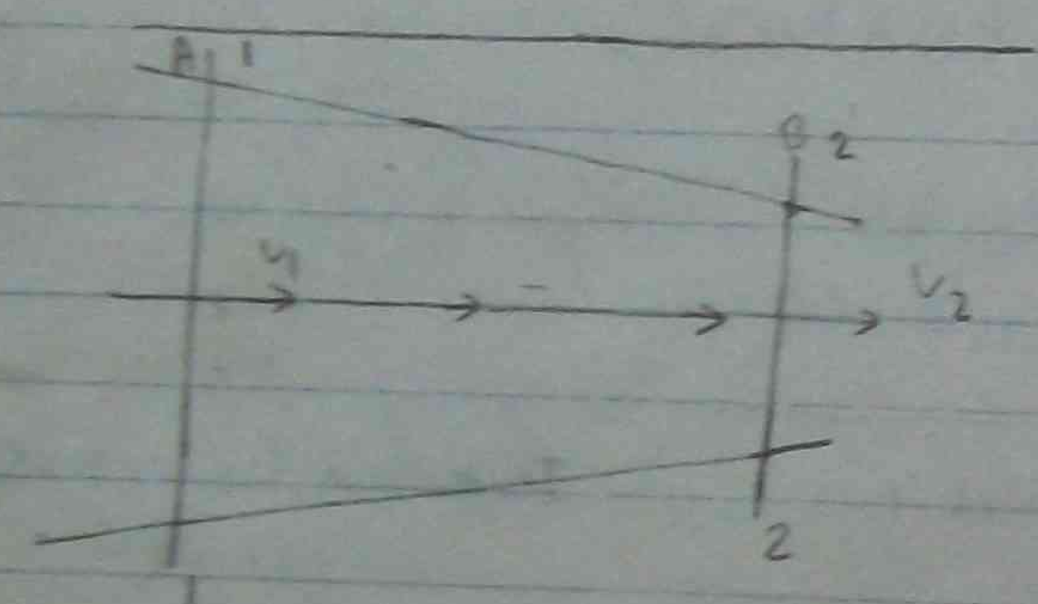
$$\boxed{Q = v \times a \quad ft^3/sec}$$

$$W\ lb/sec = Q\ ft^3/sec \times \frac{w\ lb}{1\ ft^3} \quad (w = [illegible]\ density)$$

$$W = Qw$$

[illegible]

Equation of continuity of flow



$$Q = v_1 A_1 = v_2 A_2 = v_3 A_3 \quad \text{(I)}$$

$$v_1 A_1 = v_2 A_2 \longrightarrow \text{(II)}$$

Pb (1)

[illegible] 12000 gallons/min [illegible] A [illegible] B [illegible]

$$Q = \frac{12000 \times 10}{60}\ lb/sec = \frac{\cancel{12000}^{2000}}{\cancel{60} \times 62.4}\ ft^3/sec$$

$$\therefore Q_A = a_A v_A$$

$$v_A = \frac{Q_A}{a_A} = \frac{2000}{62.4 \times \frac{\pi}{4} \times 4^2} = \frac{2000}{62.4 \times \pi \times 4}$$

$$= \frac{2000}{249.6 \times \pi} = \frac{2000}{783} = 2.55\ ft/sec$$

$$v_B = \frac{Q_B}{A_B} = \frac{2000}{62.4 \times \frac{\pi}{4} \times 4} = \frac{2000}{196} = 10.2\ ft/sec$$

pb (2)

$$* \quad 1\ ft^3 = 62.5\ lb$$

[illegible] 5 ft/sec [illegible] gallon [illegible]

$$v = 5\ ft/sec \qquad a = \frac{\pi}{4}(1)^2\ ft^2 = .7854\ ft^2$$

$$\therefore \text{Rate of flow} = v \times a$$

$$= 5 \times .7854\ ft^3/sec$$

$$= 5 \times .7854 \times 3600 \times 24\ ft^3 \quad \text{for 1 day}$$

$$lb\ [illegible] = \frac{5 \times .7854 \times 3600 \times 24 \times 62.5}{\cancel{62.5}}\ lb$$

$$\text{gallons}\ [illegible] = \frac{5 \times .7854 \times 3600 \times 24}{\cancel{62.5} \times 10} \times 62.5$$

$$= 62.5 \cdot \frac{.7854 \times 3600 \times 12}{\cancel{62.5}} = 62.5 \times \frac{.7854 \times 43200}{\cancel{62.5}} = \frac{33900 \times 62.5}{\cancel{62.5}}$$

$$= 2120000\ \text{gallons}$$

Heads Of a Liquid

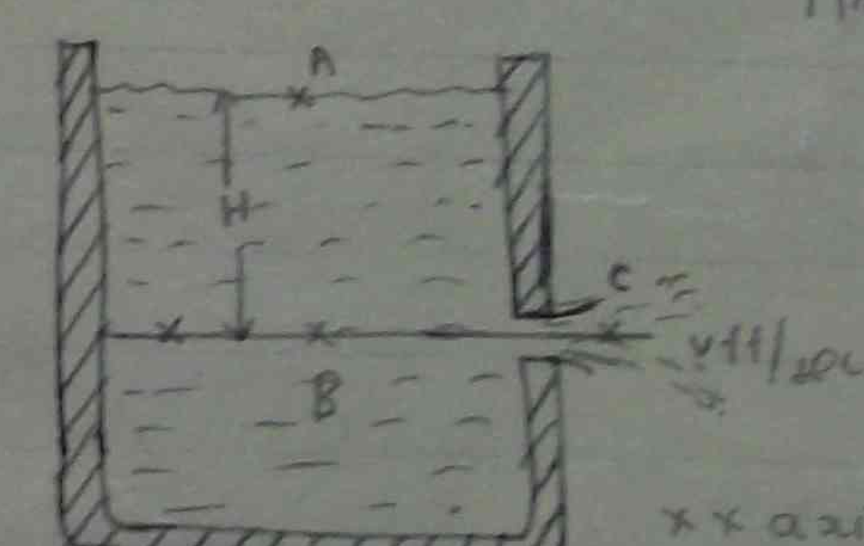
([illegible])

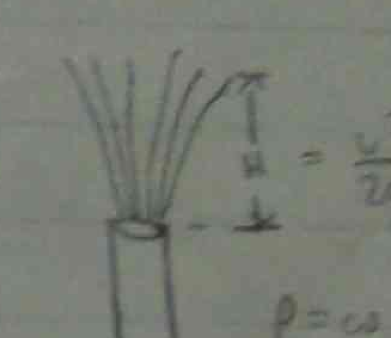
(1) Datum Head (ft) Z [illegible]

(2) Velocity Head (ft) $\left(\frac{v^2}{2g}\right)$ [illegible]

(3) Pressure Head (ft) $\left(\frac{p \times 144}{w}\right)$ ft [illegible]

$$p = lb/in^2$$





$$p = wH \quad lb/\square''$$

$$\left(H = \frac{p \times 144}{w}\right)$$

x x axis [illegible]

$$\text{Total head} = Z + \frac{v^2}{2g} + \frac{p \times 144}{w}$$

[illegible] Total head [illegible] datum head ([illegible]) [illegible] velocity head ([illegible]) [illegible] Pressure head ([illegible]) [illegible]

* Bernoulli's Theorem (6 marks) (Theorem + [illegible])

[illegible] (Particles) [illegible] Total head [illegible]

[illegible] H ft [illegible] ft/sec [illegible] A, B [illegible] C [illegible] Total head [illegible] Bernoulli's Theorem [illegible]

A [illegible] Total head = B Total head = C Total head

$$Z_A + \frac{V_A^2}{2g} + \frac{P_A \times 144}{w} = Z_B + \frac{V_B^2}{2g} + \frac{P_B \times 144}{w} = Z_C + \frac{V_C^2}{2g} + \frac{P_C \times 144}{\cancel{2g}\, w}$$

$$H + 0 + 0 = 0 + 0 + \frac{P_B \times 144}{w} = 0 + \frac{V_C^2}{2g} + 0$$

N.B. [illegible]

Pb ① 120 ft [illegible] 10 ft/sec [illegible] 60 lb/sq in [illegible] Total head [illegible]

$H = 120\text{ ft} = Z$

$V = 10\text{ ft/sec}$ $P = 60\text{ lb}/\square'' = b$

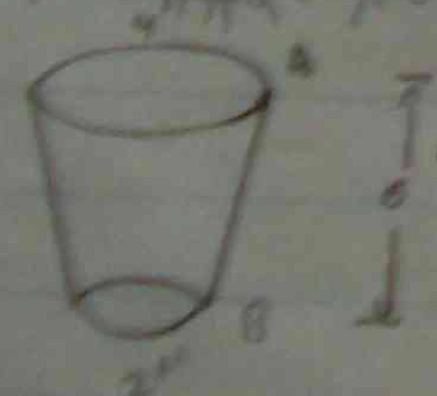
$$\text{Total head} = 120 + \frac{10^2}{2g} + \frac{60 \times 144}{62.5} \qquad g = 32.2$$

$$= 120 + \frac{256}{64.4} + \frac{8640}{62.5}$$

$$= 120 + 3.972 + 138.1$$

$$= 262.072 \text{ ft}$$

Pb ② [illegible] A [illegible] 4" [illegible] B [illegible] 2" [illegible] 6' [illegible] 300 gallons/min [illegible] A [illegible] B [illegible]



$$\text{Total head of A} \quad H_t = Z_A + \frac{V_A^2}{2g} + \frac{P_A \times 144}{w}$$

$$\text{〃 B} \quad H_t = Z_B + \frac{V_B^2}{2g} + \frac{P_B \times 144}{w}$$

$$Q = 300 \text{ gallons/min} = \frac{300 \times 10}{60} \text{ lb/sec} = 50 \text{ lb/sec}$$

$$= \frac{50}{62.5} \text{ ft}^3/\text{sec}$$

$$= .8 \text{ ft}^3/\text{sec}$$

$$Q = A_a V_a$$

$$V_A = \frac{Q}{A_a}$$

$$A_a = \frac{\pi}{4}\left(\frac{4}{12}\right)^2 = .7854 \times \frac{1}{9}$$

$$V_A = \frac{.8}{.7854 \times 1/9} = \frac{7.2}{.7854} = 9.16 \text{ ft/sec}$$

$$V_B = \frac{Q}{A_B} \qquad A_B = \frac{\pi}{4}\left(\frac{2}{12}\right)^2 = .7854 \times \frac{1}{36}$$

$$V_B = \frac{.8}{.7854 \times \frac{1}{36}} = \frac{28.8}{.7854} = 36.64 \text{ ft/sec}$$

Bernoulli's Theorem [illegible] B [illegible] Datum [illegible]

$$Z_A + \frac{V_A^2}{2g} + \frac{P_A \times 144}{w} = Z_B + \frac{V_B^2}{2g} + \frac{P_B \times 144}{w}$$

$Z_B - Z_A = -6'$

$$\cancel{Z_A - Z_B} + \frac{(P_A - P_B)\,144}{w} = Z_B - Z_A + \frac{V_B^2 - V_A^2}{2g}$$

$$\frac{(P_A - P_B)\,144}{62.4} = -6 + \frac{36.64^2 - 9.16^2}{64.4}$$

$$(P_A - P_B) = \frac{62.4}{144}\left[\frac{(36.64+9.16)(36.64-9.16)}{64.4} - 6\right]$$

$$= \frac{62.4}{144} \times \left[\frac{45.8 \times 27.48}{64.4} - 6\right]$$

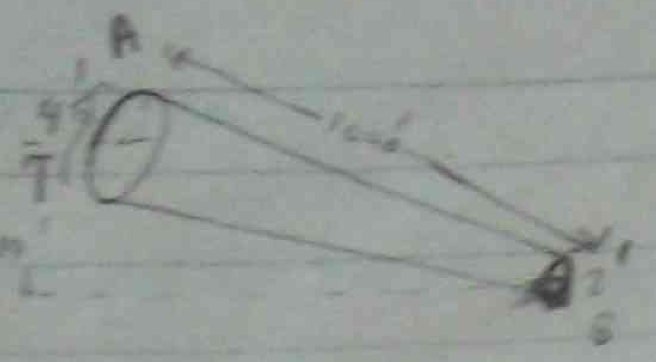
$$= \frac{62.4}{144}\left[\frac{1260}{64.4} - 6\right]$$

$$= \frac{62.4 \times 13.59}{144} = \frac{855}{144} = 5.9 \text{ lb/in}^2$$

[illegible] 855 lb/ft^2 [illegible] 5.9 lb/in^2

Pb ③

1000' [illegible] ~~1 in~~ $\frac{1}{100}$ [illegible] 4' [illegible] 2' [illegible] 12000 gallons/minute [illegible] head [illegible] 1' [illegible] 10 psi [illegible]



A [illegible] Total head $= Z_A + \frac{V_A^2}{2g} + \frac{P_A \times 144}{w}$

$Q = 12000 \text{ gallons/min} = \frac{12000}{60} \text{ lb/sec} = 2000 \text{ lb/sec}$

$2000 \text{ lb/sec} = \frac{2000}{62.5} \text{ ft}^3/\text{sec} = 32 \text{ ft}^3/\text{sec}$

$Q = A_A V_A$

$V_A = \frac{32}{\frac{\pi}{4}(4)^2} = \frac{32}{\pi \times 4} = \frac{8}{\pi} = 2.545 \text{ ft/sec}$

$V_B = \frac{32}{\frac{\pi}{4} \times (2)^2} = \frac{32}{\pi} = 10.2 \text{ ft/sec}$

A [illegible] Total head = [illegible] head + B [illegible] Total head

$Z_A + \frac{V_A^2}{2g} + \frac{P_A \times 144}{w} = H_{(LOSS)} + Z_B + \frac{V_B^2}{2g} + \frac{P_B \times 144}{w}$

[illegible] $Z_A = 10 \quad Z_B = 0$

$10 + \frac{2.545^2}{64.4} + \frac{P_A \times 144}{62.5} = 1 + 0 + \frac{10.2^2}{64.4} + \frac{P_B \times 144}{62.5}$

$10 + \frac{6.47}{64.4} + \frac{P_A \times 144}{62.5} = 1 + \frac{100.4}{64.4} + \frac{P_B \times 144}{62.5}$

$10 + .1005 + \frac{144 P_A}{62.5} = 1 + 1.56 + \frac{P_B \times 144}{62.5}$

$10.1005 + \frac{144 P_A}{62.5} = 2.56 + \frac{P_B \times 144}{62.5}$

$10.1005 - 2.56 = \frac{144}{62.5}(P_B - P_A)$

$7.5405 = 2.305 (P_B - P_A)$

$P_B - P_A = 3.27$

$P_B = 10 + 3.27 = 13.27 \text{ lb/in}^2$

Pb (4) [illegible] 1' [illegible] 6'' [illegible] 3.15 lb/in² [illegible] gallons [illegible]

$P_A - P_B = 3.15 \text{ lb/in}^2$

$P_A = (3.15 + P_B) \text{ lb/in}^2$

$Z_A = Z_B = 0$

$A_A = \frac{\pi}{4}(1)^2 = .7854 \text{ sq ft}$

$A_B = \frac{\pi}{4}\left(\frac{1}{2}\right)^2 = \frac{.7854}{4} = .1963 \text{ sq ft}$

$Z_A + \frac{V_A^2}{2g} + \frac{P_A \times 144}{w} = Z_B + \frac{V_B^2}{2g} + \frac{P_B \times 144}{w}$

$\frac{(P_A - P_B)144}{62.5} = \frac{V_B^2 - V_A^2}{2g}$

$\frac{3.15 \times 144}{62.5} \times 64.4 = V_B^2 - V_A^2$

$\frac{454 \times 64.4}{62.5} = V_B^2 - V_A^2$

$V_B^2 - V_A^2 = \frac{29150}{62.5} = 468 \quad \text{— (1)}$

$Q = A_A V_A \qquad Q = A_B V_B$

$A_A V_A = A_B V_B$

$\frac{\pi}{4} \times V_A = \frac{\pi}{4} \times \frac{1}{4} \times V_B$

$V_B = 4 V_A \qquad \therefore V_B^2 = 16 V_A^2$

$16 V_A^2 - V_A^2 = 468$

$V_A^2 = \frac{468}{15} = 31.25$

$V_A = \sqrt{31.25} = 5.6 \text{ ft/sec}$

$Q = AV$

$= .7854 \times 5.6 \text{ ft}^3/\text{sec}$

$= 4.4 \text{ ft}^3/\text{sec}$

$= 4.4 \times 24 \times 3600 \text{ ft}^3/\text{day}$

$= \frac{4.4 \times 86400 \times 62.5}{10} \text{ gallons/day}$

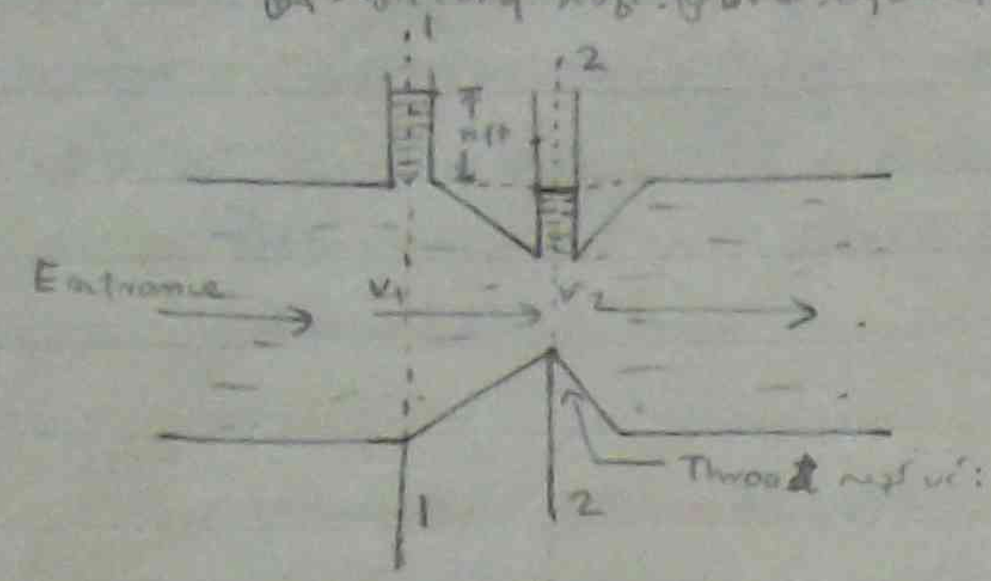
$= 380{,}000 \times 6.25 \text{ gallons/day}$

$= 2378000 \text{ gallons/day}$

2366000

VENTURI METER

[illegible]



[illegible] venturi meter [illegible]

[illegible] meter [illegible]

Bernoulli's theorem [illegible] meter [illegible] Q [illegible]

$H =$ venturi meter [illegible] (ft)

$A_1 =$ [illegible] meter [illegible] (ft²)

$A_2 =$ [illegible] meter [illegible] area (ft²)

$$Q = v_1 A_1 = v_2 A_2$$

Bernoulli's Equation [illegible]:—

$$Z_1 + \frac{v_1^2}{2g} + \frac{P_1 \times 144}{\omega} = Z_2 + \frac{v_2^2}{2g} + \frac{P_2 \times 144}{\omega}$$

$Z_1 = Z_2 = 0$ (∵ meter [illegible])

$$\frac{(P_1 - P_2)144}{\omega} = \frac{v_2^2 - v_1^2}{2g}$$

$$H = \frac{v_2^2 - v_1^2}{2g} \quad \text{—— (1)}$$

$$v_1 A_1 = v_2 A_2$$

$$v_1 = \frac{v_2 A_2}{A_1}$$

$$(1) \rightarrow \quad 2gH = v_2^2 - v_2^2 \left(\frac{A_2}{A_1}\right)^2$$

$$2gH = v_2^2 \left[1 - \left(\frac{A_2}{A_1}\right)^2\right]$$

$$V_2 = \sqrt{\frac{2gH}{1 - \left(\frac{A_2}{A_1}\right)^2}}$$

$$= \frac{2gH A_1^2}{A_1^2 - A_2^2}$$

$$\therefore Q = \frac{\sqrt{A_2^2\, 2gH\, A_1^2}}{\sqrt{A_1^2 - A_2^2}} = \sqrt{\frac{A_1^2 A_2^2\, 2g}{A_1^2 - A_2^2}} \times \sqrt{H}$$

$$C = \sqrt{\frac{A_1^2 A_2^2\, 2g}{A_1^2 - A_2^2}} \quad ※$$

C = venturimeter [illegible] constant

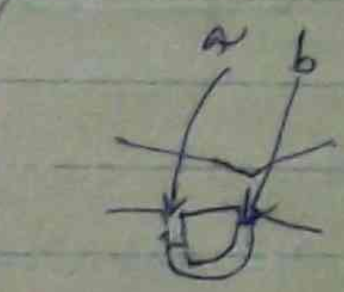
$Q = C\sqrt{H}$ ※

$Q = KC\sqrt{H}$ ※

K = coefficient of venturimeter

$K < 1$

K [illegible]



$$H = \frac{h}{12}(S - 1)$$

[illegible]

Prob: (1)

venturimeter [illegible] area [illegible] 2 sq ft [illegible] area [illegible] .25 sq ft [illegible] meter [illegible] coefficient [illegible] .97 [illegible] meter [illegible] head [illegible] 9 in [illegible] meter [illegible] constant [illegible]

$A_1 = 2\,sq\,ft$, $A_2 = .25\,sq\,ft$ $\quad H = 9'' = \frac{9}{12}' = .75$

$K = .97$

$$C = \sqrt{\frac{A_1^2 A_2^2\, 2g}{A_1^2 - A_2^2}}$$

$$= \sqrt{\frac{2 \times 2 \times (.25)^2 \times 2 \times 32}{2^2 - .25^2}}$$

$$= \sqrt{\frac{4 \times .0625 \times 64}{4 - .0625}} = \sqrt{\frac{256 \times .0625}{3.9375}} = \sqrt{\frac{16}{3.9375}} = \sqrt{4.07}$$

$$= 2.068$$

$$Q = KC\sqrt{H} = .97 \times 2.06\,\sqrt{.75}$$

$$= 1.998 \times .866$$

$$= 1.73 \text{ cu ft/sec}$$

Prob. [illegible] water [illegible] 3" [illegible] 6" [illegible] meter

[illegible] coefficient [illegible] .97 [illegible] meter [illegible] U Tube [illegible]

[illegible] U Tube [illegible] 7" [illegible] meter [illegible] constant

[illegible] $s = 13.6$

$h = \frac{h}{12}(s-1)$

$A_1 = \text{Area} = \frac{\pi}{4} \times \frac{6^2}{12 \times 12} = \frac{\pi}{16}$ sq ft

$A_2 = \text{Area} = \frac{\pi}{4} \times \frac{3^2}{12 \times 12} = \frac{\pi}{64}$ sq ft

$K = .97$

$$c = \sqrt{\frac{A_1^2 A_2^2 \, 2g}{A_1^2 - A_2^2}}$$

$$= \sqrt{\frac{(\frac{\pi}{16})^2 \times (\frac{\pi}{64})^2 \times 2 \times 32}{(\frac{\pi}{16})^2 - (\frac{\pi}{64})^2}}$$

$$= \frac{\frac{\pi}{16} \times \frac{\pi}{64} \sqrt{64}}{\sqrt{(.1963)^2 - (.049)^2}} = \frac{\frac{9.87}{16 \times 8}}{\sqrt{.0386 - .002405}} = \frac{.0772}{\sqrt{.036195}}$$

$$= \frac{.0772}{.19} = .406$$

h = [illegible]

[illegible]

$\left[\frac{P_1 \times 144}{\omega} + x + \frac{7}{12}\right]$ ft of water $= \left[\frac{P_2 \times 144}{\omega} + x + \frac{7}{12} \times s\right]$ ft of water

$$\frac{(P_1 - P_2) \times 144}{\omega} = \frac{7}{12} \times 13.6 - \frac{7}{12}$$

$$h = \frac{7}{12}(13.6 - 1) \text{ ft of water} = 7.35 \text{ ft}$$

$$Q = cK\sqrt{h}$$
$$= .406 \times .97 \sqrt{7.35}$$
$$= 1.063 \text{ ft}^3/\text{sec} \leftarrow \text{Ans}$$

WATER JET [illegible] HORSE POWER

[illegible]

water jet [illegible] v ft/sec

[illegible] area A ft²

[illegible] water jet [illegible] $= \frac{v^2}{2g}$ ft/sec

water jet [illegible] $= W$ lb/sec

water jet [illegible] power $= \frac{Wv^2}{2g}$ ft-lb/sec

$W = \omega Q = \omega v A$ lb/sec

water jet [illegible] power $= \frac{\omega A v^3}{2g}$ ft-lb/sec

$\therefore$ water jet [illegible] HP $= \frac{\omega A v^3}{2g \times 550}$

Prob: water jet [illegible] 20 ft/sec [illegible] 2" [illegible]

[illegible]

$V = 20$ ft/sec $\quad \omega = 62.5$ lb/ft³

dia. = 2" $\quad g = 32.2$

Area of jet $= \frac{22}{7 \times 4} \times \frac{2}{12} \times \frac{2}{12} = \frac{\pi}{144}$ sq ft

$$\therefore HP = \frac{\omega a v^3}{2g \times 550}$$

$$= \frac{62.5 \times \frac{\pi}{144} \times 20 \times 20 \times 20}{2 \times 32.2 \times 550}$$

$$= \frac{62.5 \times \frac{\pi}{144}}{64.4} \times \frac{8000}{550}$$

$$= \frac{196.2 \times 8000}{9280 \times 550}$$

$$= \frac{1570000}{5110000} = .308 \text{ HP}$$

Prob: A jet of water one in dia. has a velocity of 60 ft/sec find the HP of the jet

Area of jet $= \frac{\pi}{4}(1)^2 = \frac{\pi}{4} \times \frac{1}{144}$

$HP = \frac{\omega a v^3}{2g \times 550} = \frac{62.5 \times .7854 \times 60 \times 60 \times 60}{144 \times 2 \times 32.2 \times 550} = \frac{49.1 \times 216000}{[illegible]}$

$= \frac{10600000}{5100000} = 2.08$ HP

VORTEX ([illegible])

1. Free water ([illegible])
2. Forced vortex ([illegible])

[illegible] vortex [illegible]

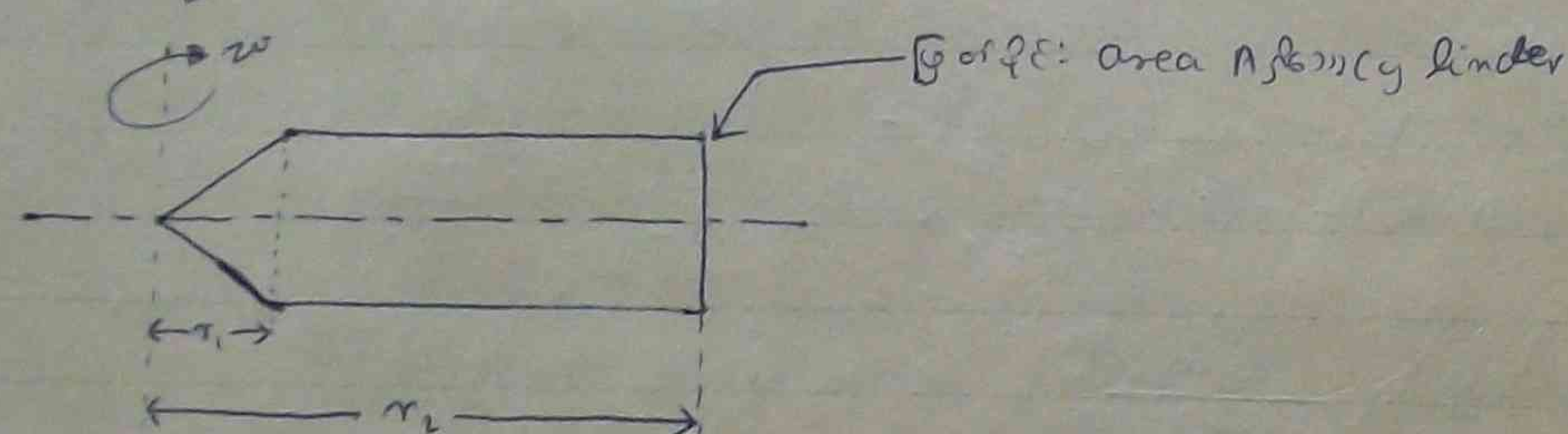
① Free vortex

[illegible] free vortex [illegible] free vortex [illegible]

② Forced vortex

[illegible] forced vortex [illegible] centrifugal head ([illegible]) [illegible]

[illegible] centrifugal pump [illegible] forced vortex [illegible]



[illegible] cylinder [illegible] $= F_c = \dfrac{w\,a\,w^2 (r_2^2 - r_1^2)}{2g}$

cylinder [illegible] $= p$

$$\frac{F_c}{a} = \frac{w (r_2^2 - r_1^2)}{2g} \quad lb/ft^2$$

cylinder [illegible] centrifugal head =

$$H_c = \frac{p}{w} = \frac{r_2^2 - r_1^2}{2g}$$

$V = \dfrac{\pi d N}{60}$ $N = r.p.m$

$H_c = \dfrac{v_2^2 - v_1^2}{2g}$ or $\dfrac{w^2 (r_2^2 - r_1^2)}{2g}$ $V_r = w r$

$V: ft$ $r = ft$

w = radian/sec

S.S.P TSN ② book ②

Prob: [illegible] centrifugal pump [illegible] impeller [illegible] axial direction [illegible] impeller [illegible] radial direction [illegible] pump [illegible] pump [illegible] 2' [illegible] 3.5' [illegible] pump [illegible] 300 r.p.m [illegible] pump [illegible] centrifugal head [illegible]

$r_1 = 2\,ft \qquad r_2 = 3.5\,ft$

velocity of pump $= v = 300$ R.P.M

$v_1 = \dfrac{300}{60} \times 2\pi \times 2$ = velocity of wheel at inlet

$= 62.8\ ft/sec$

$v_2 = 62.8 \times \dfrac{3.5}{2}$

$= 110\ ft/sec$

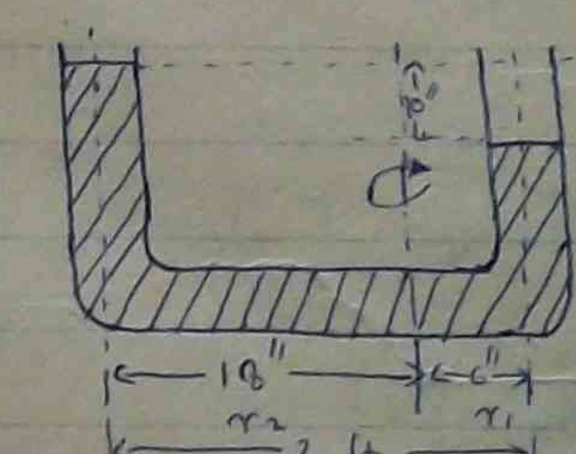
Centrifugal head $= \dfrac{v_2^2}{2g} - \dfrac{v_1^2}{2g}$

$= \dfrac{110^2 - 62.8^2}{2g}$

$= 126.7$ ft of water

S.S.P

Prob: [illegible] U tube [illegible] 2' [illegible] U tube [illegible] 18" [illegible] 10" [illegible] U tube [illegible] r.p.m [illegible]



$H' = \dfrac{v_2^2 - v_1^2}{2g}$ $\qquad V_2 = w r_2$, $V_1 = w r_1$

$H' = 10'' = \dfrac{10}{12} = 5/6\ ft$

$r_1 = 6'' = 1/2\ ft$

$r_2 = 18''\ \ 1\tfrac{1}{2}\ ft$

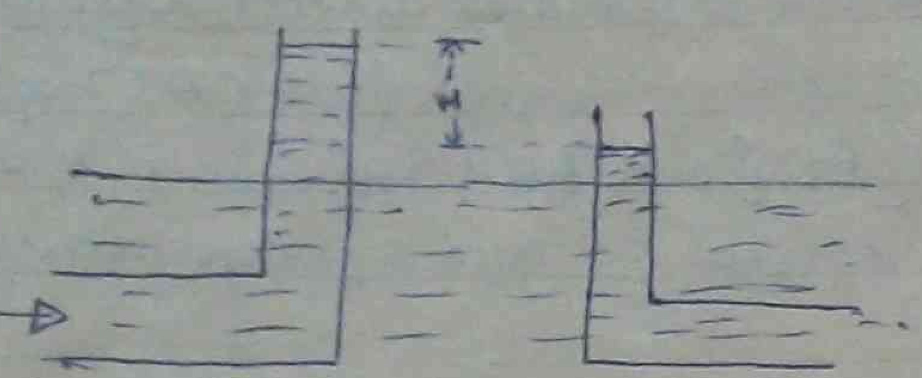
$$H' = \frac{w^2 (r_2^2 - r_1^2)}{2g}$$

$$w^2 = \frac{H' \times 2g}{r_2^2 - r_1^2} = \frac{5 \times 2 \times 32}{6 \times (9/4 - 1/4)} = 80/3$$

$$w = \sqrt{26.67} = 5.16 \text{ radians/sec}$$

PITOT TUBE

([illegible])



Pitot tube [illegible]

[illegible]

[illegible] velocity head [illegible]

[illegible] velocity head [illegible]

[illegible] velocity head [illegible] pressure head [illegible] velocity head [illegible] pressure head [illegible] velocity head [illegible]

$$\text{Velocity head} = H = \frac{v^2}{2g}$$

$$v = \sqrt{2gH} \quad ft/sec$$

[illegible] coefficient [illegible]

$$H = k\frac{v^2}{2g}$$

$$v^2 = \frac{2gH}{k} \qquad v = \sqrt{\frac{2gH}{k}}$$

[illegible] $k = 1$

~~[illegible]~~

Prob: ① [illegible] pitot tube [illegible] centre axis [illegible] $1\frac{1}{2}''$ [illegible]

$H = 1\frac{1}{2}'' = \frac{1}{8}'$

$g = 32\ ft/sec^2 \qquad k = 1 \qquad v = \sqrt{\frac{2gH}{k}} = \sqrt{\frac{2\times 32\times 1/8}{1}} = \sqrt{8} = 2.82\ ft/sec$

[illegible] $= Q = v\,A\ cu\,ft/sec$

$= 2.82 \times \frac{\pi}{4} d^2$

$= 2.82 \times \frac{22}{7\times 4} \times \frac{8}{12} \times \frac{8}{12}$

$= 2.82 \times \frac{11}{14} \times \frac{64}{144}$

$= \frac{31.02}{144} \times \frac{8}{18}$

$= \frac{248.16}{2520} = .98\ ft^3/sec$

Prob: ②

[illegible] pitot tube [illegible] tube [illegible] $3.5''$ [illegible] $\frac{2}{3}$ [illegible] cu ft/min [illegible] $10''$ [illegible]

$H = \frac{3.5''}{12} = .292' \qquad k = 1$

$v = \sqrt{2gH/k} = \sqrt{\frac{2\times 32\times .292}{1}} = \sqrt{18.7} = 4.33\ ft/sec$

[illegible] $= Q = A \times V \quad cu\,ft/sec$

[illegible] $= \frac{2}{3}$ [illegible]

$\therefore$ [illegible] $= \frac{2}{3} \times 4.33 = 2.89\ ft/sec$

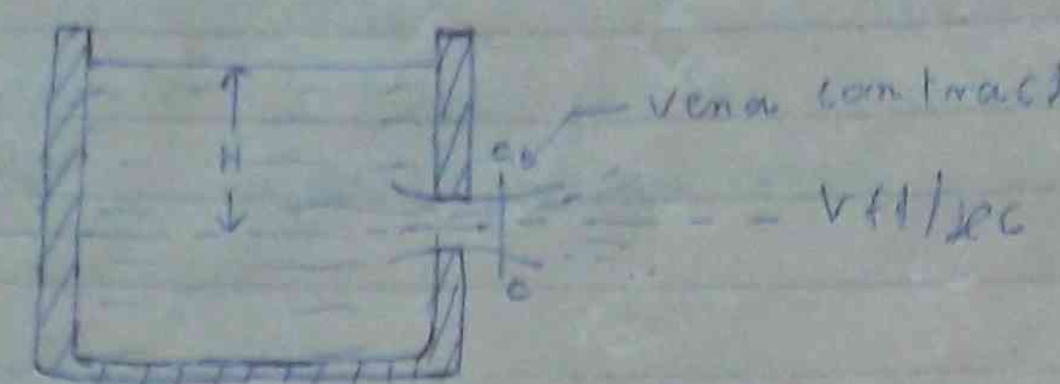
$\therefore$ [illegible] $= Q = Av$

$Q = \frac{\pi}{4}\left(\frac{10}{12}\right)^2 \times 2.89$

$= \frac{.7854 \times 64\times 2.89}{144} = 1.57\ ft^3/sec$

$ft^3/min = 1.57 \times 60\ ft^3/min = 94.2\ ft^3/min$

ORIFICES ([illegible])



orifice [illegible] ... [illegible] water jet [illegible] Vena contracta [illegible]

coeffecient of contraction = C_c [illegible]

① $C_c = \dfrac{\text{Vena Contractor [illegible] water jet [illegible] area}}{\text{[illegible] area}}$

$C_c < 1$

② coeffecient of velocity $\left[C_v = \dfrac{V}{\sqrt{2gH}} \right]$

$C_v = \dfrac{\text{actual velocity}}{\text{Theoritical velocity}} = \dfrac{V}{\sqrt{2gH}}$

$C_v < 1$

③ co-effecient of discharge = cd

$cd = \dfrac{\text{actual discharge}}{\text{Theoritical discharge}}$

$cd < 1$

[illegible] water jet [illegible] area [illegible] 64 [illegible] Theoritically [illegible] Theory [illegible] Theory [illegible] coeffecient of discharge (cd) [illegible]

cd [illegible] C_v [illegible] C_c [illegible]

$cd = C_v \times C_c$

Actual discharge = actual velocity × Actual area

$cd \times$ Theoritical discharge $= C_v \sqrt{2gH} \times C_c \times$ Area of orifice

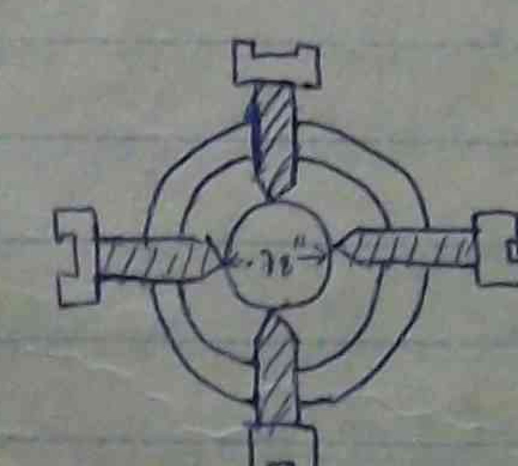
Theoritical discharge $= \sqrt{2gH} \times$ Area of orifice

$\therefore cd \sqrt{2gH} \times$ Area of orifice $= C_v \sqrt{2gH} \times C_c \times$ Area of orifice

$\therefore cd = C_v \times C_c$

1981 Prome

Pb ① [illegible] 1" [illegible] Head 4' [illegible] $3.24\ cu.ft/min$ [illegible] screw gauge [illegible] vena contracta [illegible] .78 [illegible] coeffecient of discharge cd, C_v, [illegible] C_c [illegible]



Screw gauge

$V = \sqrt{2gH} = \sqrt{2 \times 32 \times 4} = 8 \times 2 = 16\ ft/sec$

Area of orific $= \frac{\pi}{4} \left(\frac{1}{12}\right)^2 = \frac{.7854}{144} =$

Area of vena contracta $= \frac{\pi}{4}\left(\frac{.78}{12}\right)^2 = \frac{.7854 \times .608}{144}$

$C_c = \frac{.7854 \times .608}{144} \times \frac{144}{.7854} = .608\ \cancel{.648} \quad .61$ [illegible]

actual discharge [illegible] $= 3.24\ cu.ft/min = \frac{3.24}{60} = .054\ ft^3/sec$

Theotrical discharge [illegible] $= 16 \times \frac{.7854 \times 1^2}{144} = .0873\ ft^3/sec$

$\therefore cd = \frac{.054}{...} = .618 = .62$ [illegible]

$cd = \cancel{cv \times cc}$

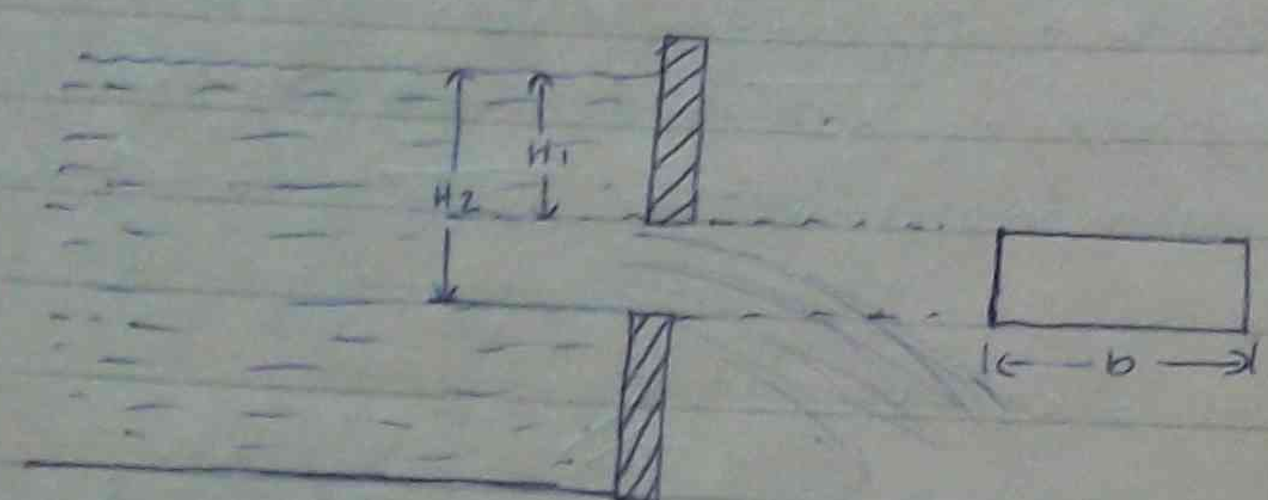
$\therefore cc = \frac{cd}{cv} = \frac{.608}{.61?} = .9$

actual $cc \times cv = cd$

$cv = \frac{cd}{cc} = \frac{.62}{.61} = \cancel{.983}\ 1$

Discharge through large orifice

(ကြီးမားသော ရေထွက်ပေါက်မှ စီးထွက်လာသော ရေထုထည်ရေစီးနှုန်း)



H_1 = အပေါ်နှုတ်ခမ်းနှင့် ရေမျက်နှာပြင်အကြား အမြင့် (ft)

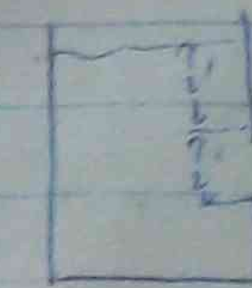
H_2 = အောက် " (ft)

b = ရေထွက်ပေါက်၏ အလျား အနံ (ft)

ရေထုထည်ရေစီးနှုန်း: $Q = \frac{2}{3} c_d\, b \sqrt{2g} \left(H_2^{3/2} - H_1^{3/2}\right)$

ဖော်ပြပါပုံတွင် H_1 သည် ကြီးမားသော ရေထွက်ပေါက် တစ်ခု၏ အပေါ်နှုတ်ခမ်းနှင့် ရေမျက်နှာပြင်အကြား အမြင့်ဖြစ်၍ H_2 သည် ရေထွက်ပေါက်၏ အောက်နှုတ်ခမ်းနှင့် ရေမျက်နှာပြင်အကြား အမြင့်ဖြစ်သည်။ ရေထွက်ပေါက်သည် ထောင့်မှန်စတုဂံပုံဖြစ်သည်။ ၎င်း၏ အနံ width or breadth သည် b ဖြစ်သည်။ ၎င်းရေထွက်ပေါက်သည် ကြီးမားနေသောကြောင့် ၎င်းမှ ဖြတ်စီးနေသော ရေထုထည်ရေစီးနှုန်းကို ရှာလိုလျှင် ဖော်ပြထားသော $Q = \frac{2}{3} cd\, b \sqrt{2g} \left(H_2^{3/2} - H_1^{3/2}\right)$ ဖြစ်သည်။

Pb① ရေလှောင်ကန်တစ်ခု၏ ဘေးနံရံတွင်ထားသော ထောင့်မှန်စတုဂံပုံ ရေထွက်ပေါက် တစ်ခု၏ အနံသည် 4' ဖြစ်၍ အမြင့်သည် 2' ဖြစ်သည်။ ရေမျက်နှာပြင်သည် အပေါ်နှုတ်ခမ်းအထက် 2' အကွာတွင်ရှိသည်။ $C_d = .62$ ဖြစ်လျှင် ၎င်းရေထွက်ပေါက်တွင် ဖြတ်စီးနေသော ရေထုထည်ရေစီးနှုန်းကို ရှာပါ။



b = 4' H_1 = 2' H_2 = 4'

$Q = \frac{2}{3} cd\, b \sqrt{2g} \left(H_2^{3/2} - H_1^{3/2}\right)$

$= \frac{2}{3} \times .62 \times 4 \sqrt{2 \times 32} \left(4^{1.5} - 2^{1.5}\right)$

$= \frac{4.96}{3} \times 8\ (8 - 2.83)$

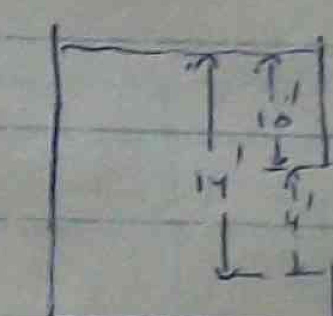
$= 1.653 \times 8 \times 5.17$

$= 8.55 \times 8$

$= 68.5\ ft^3/sec$

② ကျယ်ပြန့်သော ထောင့်မှန်စတုဂံပုံရှိသော ရေထွက်ပေါက်တစ်ခု၏ အနံသည် 6' ဖြစ်၍ အမြင့်သည် 4' ဖြစ်သည်။ ရေမျက်နှာပြင်သည် အပေါ်နှုတ်ခမ်းအထက် 10' အကွာတွင် ရှိနေလျှင် ရေထုထည်ရေစီးနှုန်းကို ရှာပါ။ Cd = .6

(က) 1 နာရီအတွင်း စီးသော ရေထုထည်ရေစီးနှုန်းကို ရှာပါ။



$H_1 = 10'$ $H_2 = 14'$ $b = 6'$

$Q = \frac{2}{3} cd\, b \sqrt{2g} \left(H_2^{3/2} - H_1^{3/2}\right)$

$= .667 \times .6 \times 6 \sqrt{2 \times 32} \left(14^{1.5} - 10^{1.5}\right)$

$= 2.4 \times 8\ (52.2 - 31.6)$

$= 19.2 \times 20.6$

$= 395.8\ ft^3/sec$ gallons ဖြင့်ဆိုလျှင် $= 395.8 \times 6.25$

$= 2475$ gallons/sec

for 1 hr $= 395.8 \times 3600$

$= 1423000\ ft^3/hr$

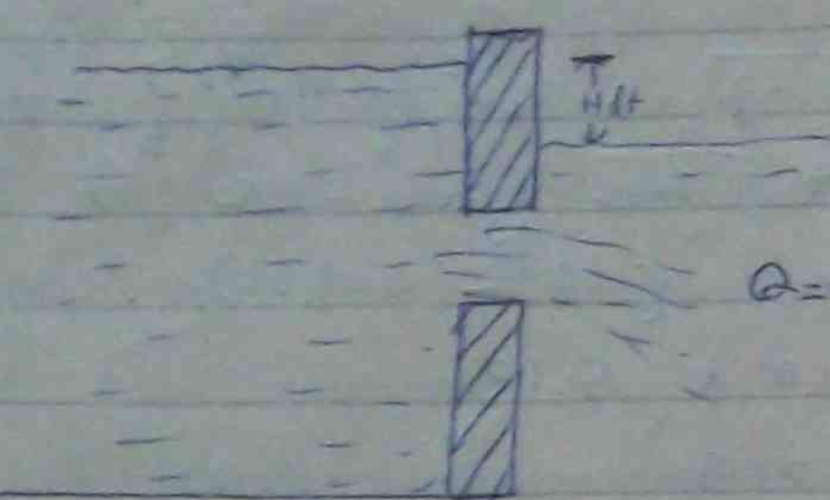
gallo lb ဖြင့်ဆိုလျှင် $= 1423000 \times 62.5$ lb/hr

gallon ဖြင့်ဆိုလျှင် $= 1423000 \times 6.25$ gallons/hr

$= 8890000.0$

Drowned Orifice

([illegible])



$$Q = cd\,v\,A$$

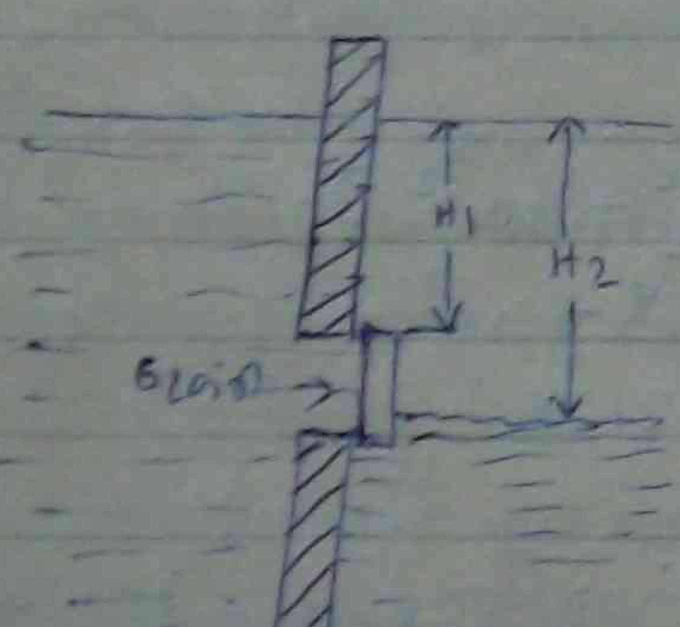
$$v = \sqrt{2gH}$$

$$Q = cd\,A\sqrt{2gH} \quad ft^3/sec$$

Orifice [illegible] drowned orifice [illegible] Orifice [illegible] head [illegible]

Partially Drowned Orifice

[illegible]



$$Q\ \text{Total} = Q_1\ \text{large} + Q_2\ \text{Drown}$$

$$= \frac{2}{3} cd\,b\sqrt{2g}\,(H_2^{3/2} - H_1^{3/2}) + cd \times A_2\sqrt{2gH_2}$$

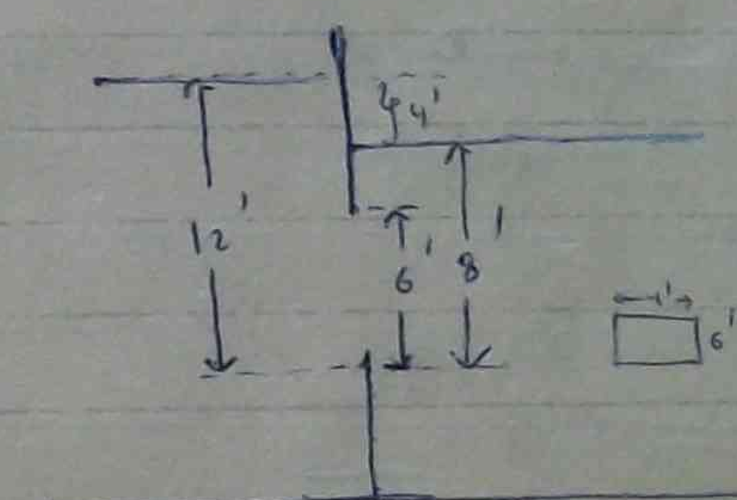
A_2 = [illegible] area ft^2

Orifice [illegible] partially drowned orifice [illegible]

[illegible] large orifice [illegible] drowned orifice [illegible]

Prob ①

[illegible] 4' [illegible] 8' [illegible] 12' [illegible] $cd = .62$ [illegible] (a) [illegible] (b) [illegible] 4' [illegible]



$$H = 12 - 8 = 4'$$

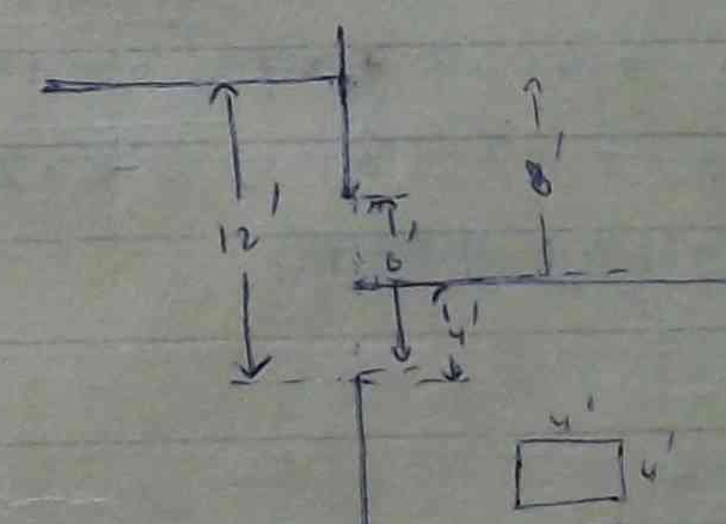
$$Q = cd\,A\sqrt{2gH}$$

$$= .62 \times 4 \times 6 \times \sqrt{2 \times 32.2 \times 4}$$

$$= 24 \times .62 \times \sqrt{257.6}$$

$$= 14.88 \times 16.05$$

$$= 239\ ft^3/sec$$



[illegible] $Q = cd\,A\sqrt{2gH}$

$$Q = .62 \times 4 \times 4 \times \sqrt{2 \times 32.2 \times 8}$$

[illegible] $Q = \frac{2}{3} cd\,b\sqrt{2g}\,(H_2^{3/2} - H_1^{3/2})$

$$= \frac{2}{3} \times .62 \times 4\sqrt{2 \times 32.2}\,(8^{1.5} - 6^{1.5})$$

$$Q_T = .62 \times 4 \times 4 \times \sqrt{2 \times 32.2 \times 8} + \frac{2}{3} \times .62 \times 4\sqrt{2 \times 32.2}\,(8^{1.5} - 6^{1.5})$$

$$= 9.93 \times \sqrt{515} + .667 \times 2.48 \times \sqrt{64.4}\,(22.65 - 14.70)$$

$$= 9.93 \times 22.7 + 1.655 \times 8.02 \times 7.95$$

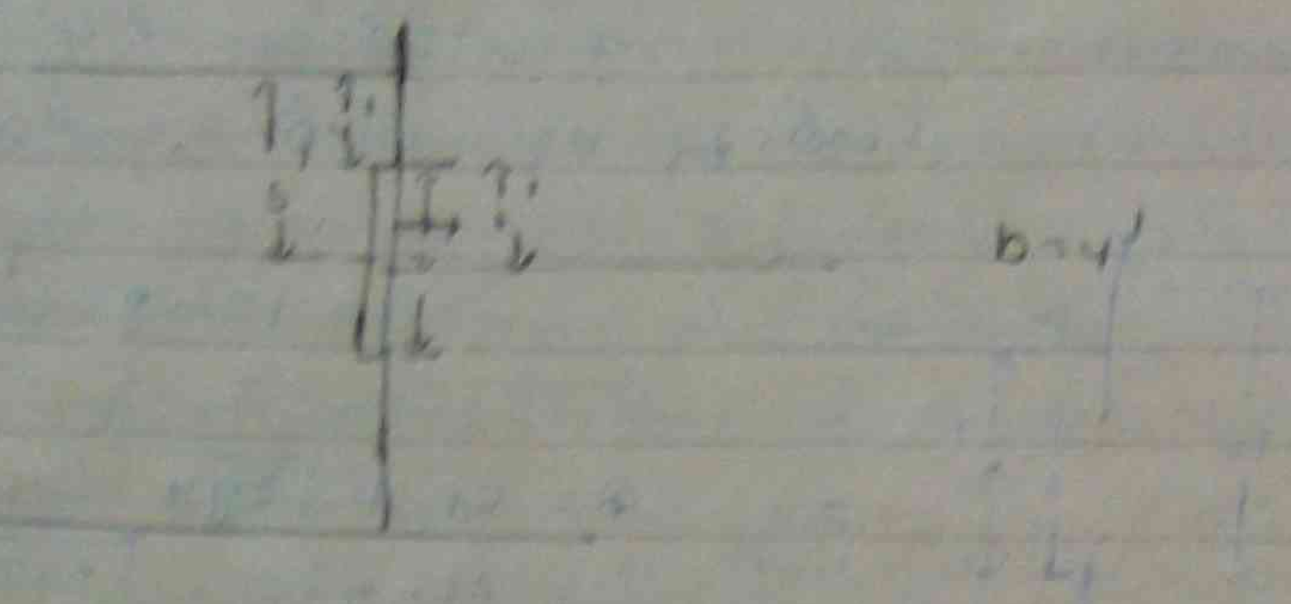
$$= 225 + 1.655 \times 63.7$$

$$= 225 + 105.8$$

$$= 330.8\ ft^3/sec$$

Prob (3)

[illegible]



$$Q = \frac{2}{3} c_d\, b \sqrt{2g}\,(H_2^{3/2} - H_1^{3/2}) + c_d A \sqrt{2gH}$$

$= \frac{2}{3} \times .62 \times 4 \sqrt{2 \times 32.2}\,(5^{1.5} - 4^{1.5}) + .62 \times 1 \times 4 \sqrt{64.4 \times 5}$

$= .667 \times 2.48 \times 8.02\,(11.2 - 8) + 2.48 \sqrt{322.2}$

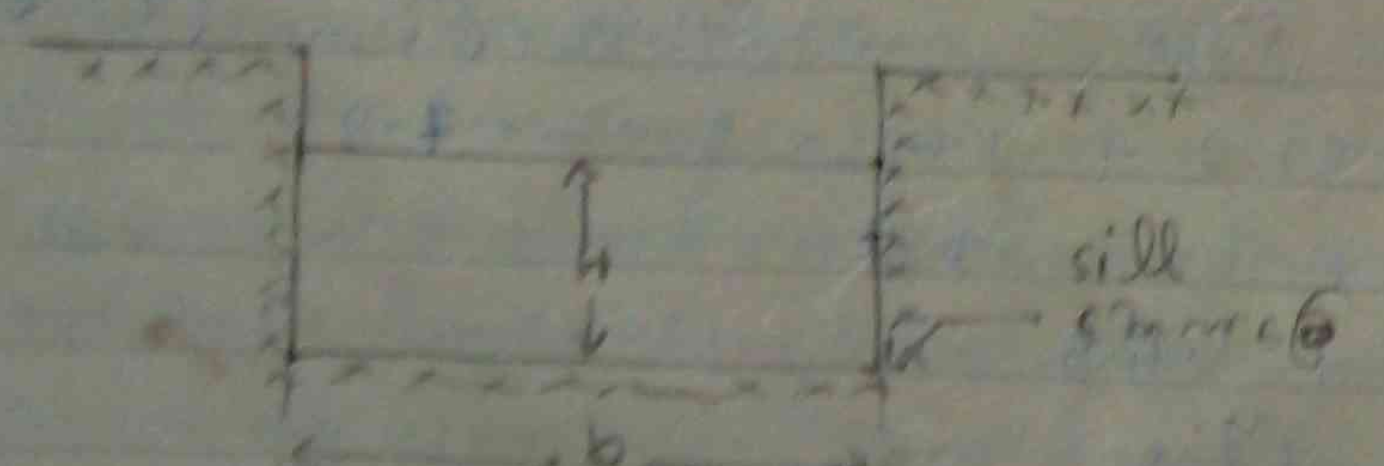
$= 1.655 \times 8.02 \times 3.2 + 2.48 \times 17.95$

$= 13.25 \times 3.2 + 44.6$

$= 42.4 + 44.6$

$= 87.0\ ft^3/sec$

WEIR OR NOTCH



Retangular weir

weir [illegible] critical [illegible] Notch [illegible] weir [illegible]

[illegible] Retangular [illegible] weir [illegible]

Retangular weir H = [illegible] sill [illegible] (ft)

$$Q = \frac{2}{3} c_d\, b \sqrt{2g}\, H^{3/2}$$

Prob (1)

6' [illegible] Retangular weir [illegible] sill [illegible] 2' [illegible]

$c_d = .6$

$Q = \frac{2}{3} c_d\, b \sqrt{2g}\,(H^{3/2})$

$= \frac{2}{3} \times .6 \times 6 \sqrt{2 \times 32.2} \times 3^{3/2}$

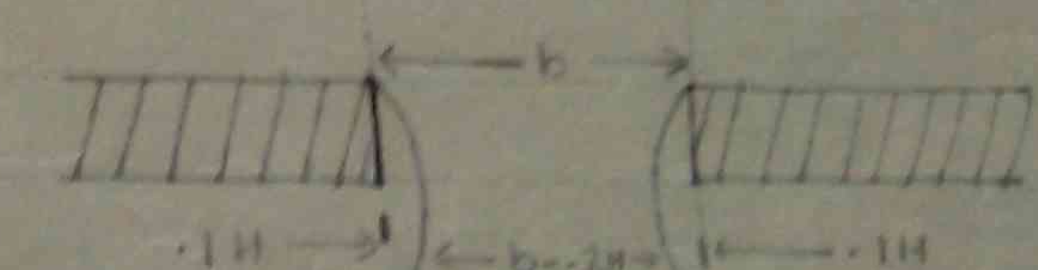
$= .4 \times 6 \times 8.02 \times 5.2$

$= 2.4 \times 41.63$

$= 99.9\ ft^3/sec$

FRANCIS'S FORMULA

for Rectangular weir



[illegible] end contraction [illegible]

$$Q = \frac{2}{3} c_d \sqrt{2g}\,(b - .2H)\, H^{3/2}\ ft^3/sec$$

1981 Prome

Prob: (2)

[illegible] Rectangular weir [illegible] head [illegible] 2 ft [illegible] $c_d = .63$ [illegible] gallon [illegible] Francis's formula [illegible]

$$Q = \frac{2}{3} c_d \sqrt{2g}\,(b - .2H)\, H^{3/2}$$

$= .667 \times .63 \times \sqrt{64.4}\,(6 - .2 \times 2) \times 2^{1.5}$

$= .42 \times 8.02 \times 5.6 \times 2.83$

[illegible] gallon $= \dfrac{53.3 \times 3600 \times 24 \times [illegible]}{10 \times [illegible]}$ gallons

for 1 year $= \dfrac{53.3 \times 3600 \times 24 \times 365 \times 62.5}{10}$

$ft^3 \times 62.5 = lb$ $= 192000 \times 2.4 \times 22800$

$= 192000 \times 54700$

$= 1051 \times 10^7$ gallons/year

Bazin's formula for Rectangular weir

$$Q = m b \sqrt{2g} \; H^{3/2}$$

$$m = .405 + \frac{.00984}{H}$$

Prob (3) Rectangular [illegible] head [illegible] 6" [illegible] 4' [illegible] Bazin's formula [illegible] weir [illegible]

$$Q = m b \sqrt{2g} \; H^{3/2}$$

$$m = .405 + \frac{.00984}{H}$$

$$m = .405 + \frac{.00984}{\frac{1}{2}}$$

$$= .405 + .01968 = .42468$$

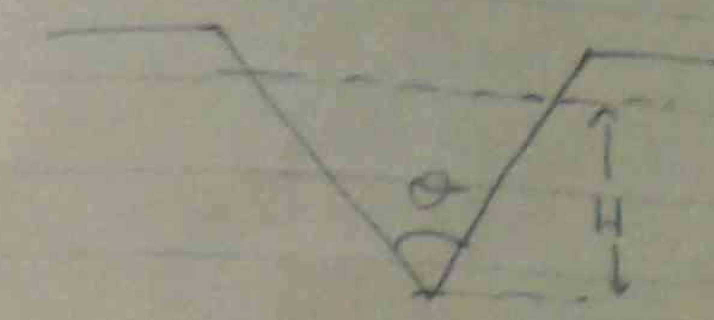
$$Q = .42468 \times 4 \sqrt{2 \times 32.2} \times (.5)^{1.5}$$

$$= 1.698 \times 8.02 \times .353$$

$$= 13.6 \times .353$$

$$= 4.82 \; ft^3/sec$$

Triangular Notch or V Notch



$$Q = \frac{8}{15} c_d \sqrt{2g} \; \tan\frac{\theta}{2} \; H^{\frac{5}{2}} \; ft^3/sec$$

1921 Prome

Prob (1)

Triangle Notch [illegible] Head 10" [illegible] notch [illegible] angle [illegible]

$c_d = .62$

$$H = \frac{10}{12} = .833 \; ft$$

$$Q = \frac{8}{15} c_d \sqrt{2g} \; \tan\frac{\theta}{2} \; H^{\frac{5}{2}}$$

$$= \frac{8}{15} \times .62 \times \sqrt{2 \times 32.2} \; \tan\frac{120}{2} \; (.833)^{2.5}$$

$$= \frac{4.96}{15} \times 8.02 \times \tan 60 \times .634$$

$$= \frac{39.7 \times 1.733}{15} \times .634$$

$$= \frac{68.8 \times .634}{15} = \frac{43.6}{15} = 2.91 \; ft^3/sec$$

Prob (2) Right angled notch [illegible] Head [illegible] 18" [illegible] $c_d = 0.6$ [illegible]

$$Q = \frac{8}{15} c_d \sqrt{2g} \; \tan\frac{\theta}{2} \; H^{\frac{5}{2}}$$

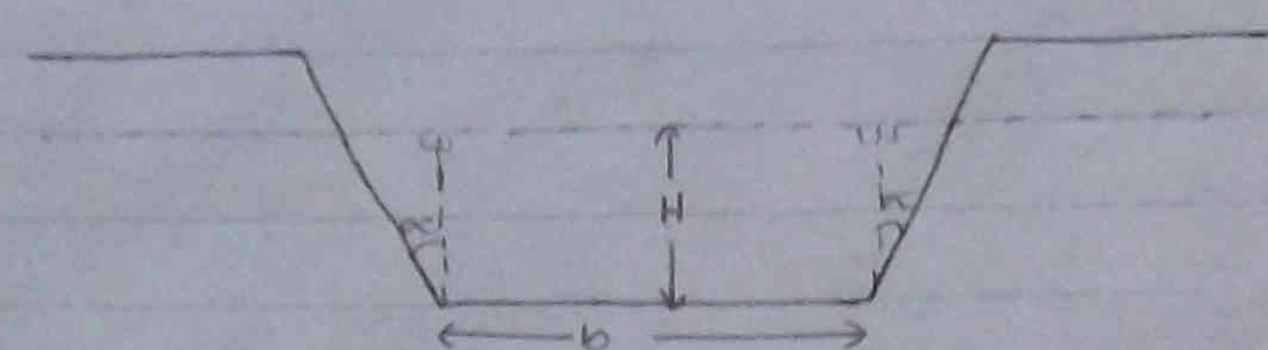
$$= \frac{8}{15} \times .6 \sqrt{2 \times 32.2} \; \tan\frac{90}{2} \times 1.5^{2.5}$$

$$= .32 \times 8.02 \times 2.76$$

$$= 2.565 \times 2.76$$

$$= 7.06 \; ft^3/sec$$

TRAPEZOIDAL NOTCH



[illegible] (Trapezium) Notch [illegible] Notch [illegible] Triangle notch [illegible] Notch [illegible] rectangular Notch [illegible] Triangular notch [illegible]

$$Q = \frac{2}{3} c_d b \sqrt{2g}\, H^{\frac{3}{2}} + \frac{8}{15} c_d \sqrt{2g} \tan\frac{\alpha}{2}\, H^{\frac{5}{2}}$$

$$Q = \frac{2}{3} c_d \sqrt{2g}\, H^{\frac{3}{2}} \left[b + \frac{4}{5} \tan\alpha\, H \right]$$

Pb① [illegible] Notch [illegible] 15' [illegible] 45 [illegible] Head [illegible] 4' [illegible] $c_d = .62$ [illegible] Notch [illegible] gallon [illegible]

$$Q = \frac{2}{3} c_d\, b \sqrt{2g}\, H^{\frac{3}{2}} + \frac{8}{15} c_d \sqrt{2g} \tan\frac{\alpha}{2}\, H^{\frac{5}{2}}$$

$$= \frac{2}{3} c_d \sqrt{2g}\, H^{3/2} \left[b + \frac{4}{5} \tan\alpha\, H \right] \qquad \alpha = 45$$

$$= \frac{2}{3} \times .62 \sqrt{2 \times 32.2} \times 4^{1.5} \left[15 + \frac{4}{5} \tan 45 \times 4 \right]$$

$$= \frac{1.24}{3} \times 8.02 \times 8 \left[15 + \frac{16}{5} \right]$$

$$= .4133 \times 64.16 \left[15 + 3.2 \right]$$

$$= .4133 \times 64.16 \times 18.2$$

$$= 26.5 \times 18.2$$

$$= 483\ ft^3/sec$$

$$\frac{483 \times 62.5}{10}\ gallons/_{sec} = 483 \times 6.25 = 3020\ gallons$$

$$Q = 3020 \times 3600\ gallons/_{hr}$$

$$= 3020 \times 3600 \times 24 \times 365\ gallons/_{year}$$

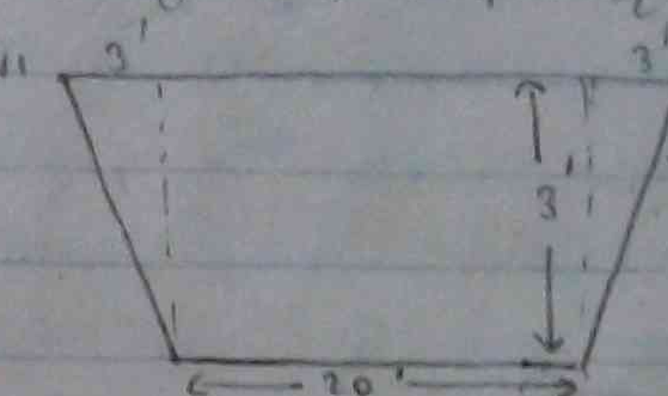
$$= 1088\,0000 \times 8760$$

$$= 950 \times 10^8\ gallons/_{year}$$

(38)

Pb① [illegible] Head [illegible] 2' [illegible] weir [illegible] 20' [illegible] $ft^3/_{sec}$ [illegible]

[illegible] 20' [illegible] side slope [illegible] 1:1 [illegible] 3' [illegible] weir [illegible] c_d [illegible]



[illegible] area $= 20 \times 3 + 2 \times \frac{1}{2} \times 3 \times 3$

$= 60 + 9$

$= 69\ ft^2$

[illegible] $= 69\ ft^2 \times 2\ ft/_{sec}$

$= 138\ ft^3/_{sec}$

weir [illegible] $Q = \frac{138}{2} = 69\ ft^3/_{sec}$

Q

$$Q = \frac{2}{3} c_d \sqrt{2g}\, H^{\frac{3}{2}} \left[b + \frac{4}{5} \tan\alpha\, H \right]$$

$$69 = \frac{2}{3} \times .62 \times \sqrt{2 \times 32.2} \times 2^{1.5} \left[b + \frac{4}{5} \tan 30 \times 2 \right]$$

$$69 = \frac{1.24}{3} \times 8.02 \times 2.83 \left[b + \frac{4}{5} \times 2 \times .577 \right]$$

$$69 = .4133 \times 22.65 \left[b + \frac{8}{5} \times .577 \right]$$

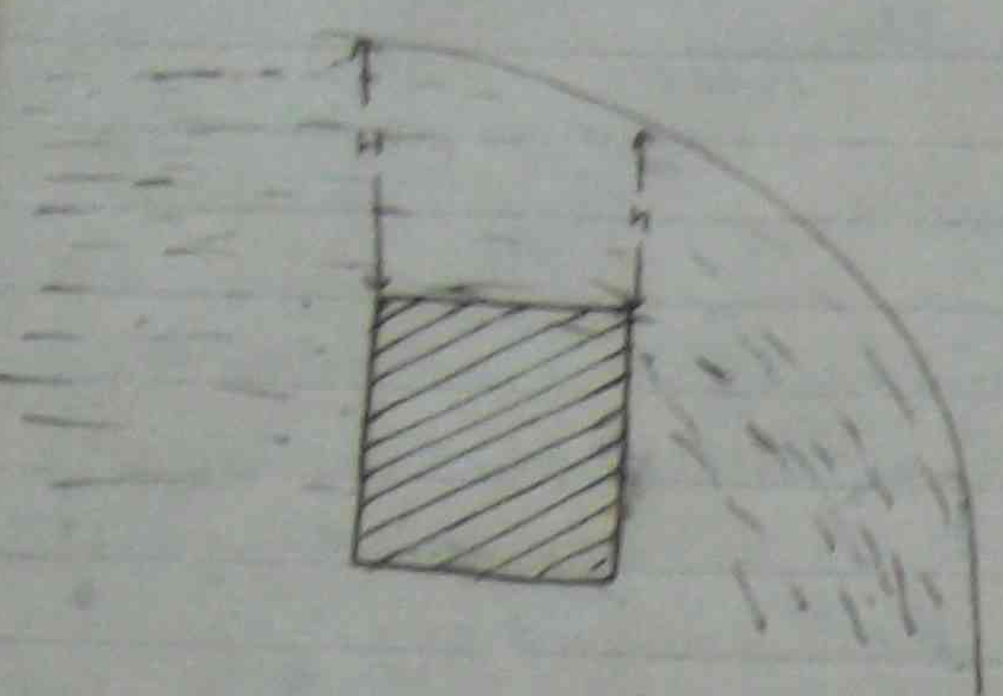
$$69 = 9.35 \left[b + 1.6 \times .577 \right]$$

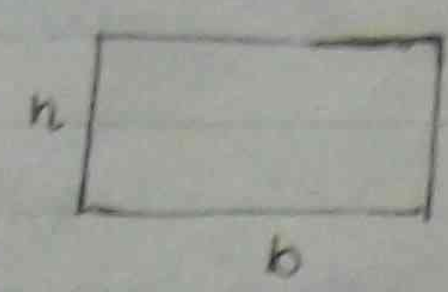
$$7.37 = b + .925$$

$$b = 7.37 - .925$$

$$= 6.245\ ft$$

Broad crested weir





$$H = h + \frac{v^2}{2g}$$

$$\frac{v^2}{2g} = H - h$$

$$v = \sqrt{2g(H-h)}$$

$$Q = cd\ VA$$

$$A = b \times h$$

$$Q = cd\ b\ h \sqrt{2g(H-h)}$$

$$Q = cd\ b \sqrt{2g(Hh^2 - h^3)}$$

[illegible] $h = \frac{2}{3} H$

$$Q_{max} = cd\ b \sqrt{2g} \sqrt{\frac{4}{27} H^3 - \frac{8}{27} H^3}$$

$$Q_{max} = cd\ b \sqrt{2g} \sqrt{\frac{4}{27} H^3}$$

$$\boxed{Q_{max} = 3.09\ cd\ b\ H^{\frac{3}{2}}}$$

Pb. [illegible] 12' [illegible] Broad crested weir [illegible]

[illegible] weir [illegible] crest [illegible] Head [illegible] 1.6' [illegible] cd = 0.97 [illegible]

b = 12' H = 1.6 cd = .97

$$Q_{max} = 3.09\ cd\ b\ H^{\frac{3}{2}}$$

$$= 3.09 \times .97 \times 12 \quad 1.6^{1.5}$$

$$= 36 \times 2.023$$

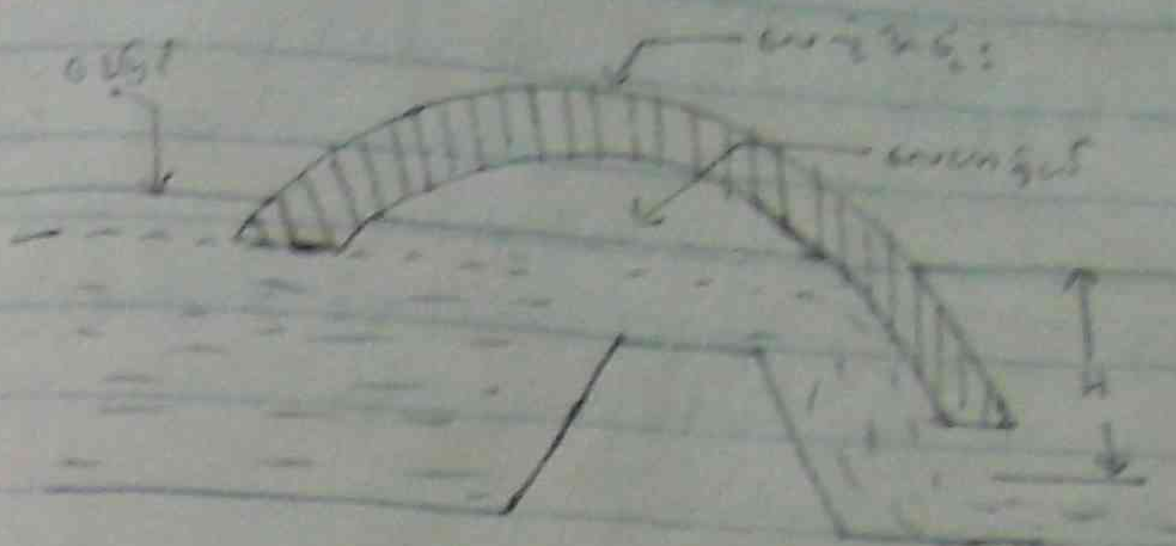
$$= 72.7\ ft^3/sec$$

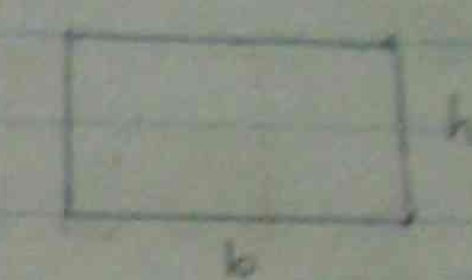
Broad crest weir

$$Q_{max} = 3.09\ cd\ b\ H^{3/2}$$

$$Q = \frac{2}{3} cd\ b \sqrt{2g}\ H^{3/2}\ \frac{2}{3\sqrt{3}}$$

SYPHON SPILLWAY





[illegible] syphon spillway [illegible] spillway [illegible] syphon spillway [illegible] weir [illegible] spillway [illegible] (velocity head [illegible]) [illegible]

[illegible] syphon spillway [illegible] Broad crested weir [illegible] spillway [illegible] crest [illegible] vacuum [illegible]

$$Q = cd\ VA$$

$$V = \sqrt{2gH}$$

$$A = b\ h$$

$$\boxed{Q = cd\ b h \sqrt{2gH}}$$

H - discharge head

h -

H = [illegible] (+)

h = crest [illegible]

55၆

၉၆

[illegible] Broad crested weir [illegible] head [illegible]
$1000\ ft^3/sec$ [illegible]
[illegible] syphon spill way [illegible]
[illegible] discharge head 60' [illegible] spill way [illegible]
syphon [illegible] 2' 3' [illegible]

(က) $Q = c_d\, b h \sqrt{2gH}$

$1000 = .95 \times b \times 2 \sqrt{2 \times 32.2 \times 60}$

$b = \dfrac{1000}{1.9 \times 8.02 \sqrt{60}} = \dfrac{1000}{15.22 \times 7.75} = \dfrac{1000}{118} = 8.47'$

(ခ) $Q = \frac{2}{3} c_d\, b \sqrt{2g}\ H^{\frac{3}{2}}\ \dfrac{2}{3\sqrt{3}}$ (Q max)

$1000 = \frac{2}{3} \times .95 \times b \sqrt{2 \times 32.2} \times 3^{1.5} \times \dfrac{2}{3 \times 1.7321}$

$b = \dfrac{1000 \times 3 \times 3 \times 1.7321}{2 \times .95 \times \sqrt{2 \times 32.2} \times 3^{1.5} \times 2}$

$= \dfrac{9000 \times 1.7321}{1.9 \times 8.02 \times 2 \times 5.2}$

$= \dfrac{15600}{15.22 \times 10.4} = \dfrac{15600}{158.2} = 98.5'$

(ဂ) $Q_{max} = 3.09\ c_d\ b\ H^{3/2}$

$\therefore b = \dfrac{1000}{3.09 \times .95 \times 3^{1.5}} = 62.3'$

(ဃ) [illegible] syphon spill way [illegible]

$Q = c_d\, b\, h \sqrt{2gH}$

$1000 = .95 \times 2\, b \sqrt{2 \times 32.2 \times 60}$

$b = \dfrac{1000}{.95 \times 2 \sqrt{2 \times 32.2 \times 60}} = 8.47'$

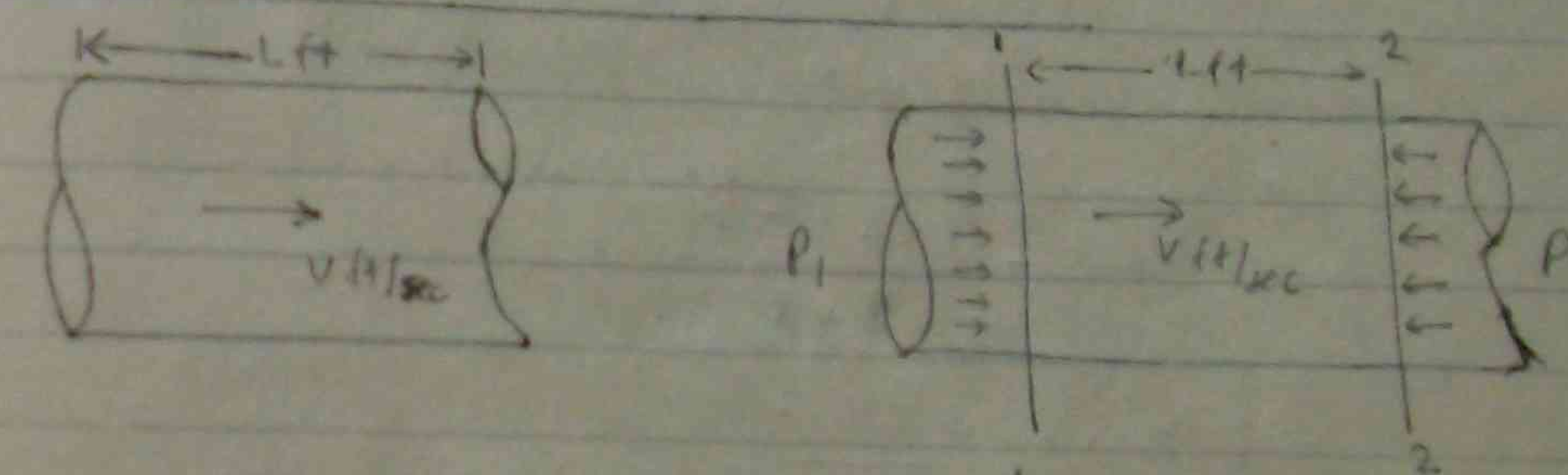
FRICTION AND FLOW THROUGH PIPES

[illegible]

[illegible]

Loss of head due to friction

[illegible]



[illegible] area (a) [illegible] L ft [illegible] 1-1 [illegible] P_1 [illegible] 2-2 [illegible] P_2 [illegible] V ft/sec [illegible] 1-1 [illegible] 2-2 [illegible] head [illegible] frictional head (h_f) ft [illegible]

[illegible]

$P_1 a = P_2 a$ + [illegible]

[illegible] $= P_1 a - P_2 a$

$= (P_1 - P_2)\, a$ lb

[illegible] $f' =$ 1 unit [illegible] 1 unit [illegible]

[illegible]

= frictional resistance per unit area per unit velocity

p = wetted perimeter

([illegible])

$\therefore$ [illegible] $= f'PLv^2$

$\therefore f'PLv^n = a(P_1 - P_2)$

[illegible]

$$\frac{f'PLv^n}{w} = \frac{f'PLv^n}{wa} = h_f$$

$\frac{a}{P} = \frac{area}{perimeter}$ ကို hydraulic mean [illegible]

$$m = \frac{a}{P} = \frac{\frac{\pi}{4}d^2}{\pi d} = \frac{d}{4}$$

$$h_f = \frac{4f'PLV^n}{wm}$$

[illegible] Turbulent flow [illegible]

$$h_f = \frac{4f'PLv^2}{wd}$$

let $f' = \frac{fw}{2g}$

$$\therefore h_f = \frac{4fLv^2w}{w2gd}$$

$$\boxed{h_f = \frac{4fLv^2}{2gd}}$$

Darcy formula

f = Darcy's frictional coefficient

Pb ① [illegible] 150' [illegible] 8 ft/sec [illegible] f = .006 [illegible] head [illegible]

$d = \frac{8}{12} = .667$ ft

$$h_f = \frac{4fLv^2}{2gd} = \frac{4\times.006\times150\times64}{2\times32\times.667}$$

$$= \frac{.024\times9600}{64\times.667}$$

$$= \frac{230}{42.7} = 5.4\ ft$$

② 1000ft [illegible] 6" [illegible] 600 gallons/min [illegible] f = .01 [illegible] head [illegible]

[illegible] $\frac{6000}{60}$ lb/sec = 100 lb/sec [illegible]

$$ft^3/sec = \frac{100}{62.5} = 1.6\ ft^3/sec$$

$$Q = A\times V$$

$$\therefore V = \frac{Q}{A} = \frac{1.6}{\frac{\pi}{4}\times\frac{1}{4}} = \frac{16\times16}{\pi}$$

$$V = \frac{25.6}{\pi} = 8.15\ ft/sec$$

$$h_f = \frac{4fLv^2}{2gd}$$

$$= \frac{4\times.01\times1000\times8.15\times8.15}{\cancel{2}\times32\times\frac{1}{\cancel{2}}}$$

$$= \frac{40\times66.4}{32} = \frac{2660}{32} = 83.2\ ft$$

A (P)

③ [illegible] 1500 [illegible] 6'' [illegible] 2 [illegible] 96' [illegible] f = .01 [illegible] 96 ft = head loss + velocity head

$$h_f = \frac{4fLv^2}{2gd} + \frac{v^2}{2g}$$

$$96 = \frac{4\times.01\times1500\times v^2}{2\times32\times\frac{1}{2}} + \frac{v^2}{2\times32}$$

$$96 = \frac{v^2}{2\times32}\left[\frac{60\times2}{\cancel{2}}+1\right]$$

$$96 = \frac{v^2}{64}\left[\frac{121}{\cancel{2}}\right]$$

$$v^2 = \frac{96\times64\times\cancel{2}}{121} = \frac{6150\times\cancel{2}}{121} = \cancel{\frac{12800}{121}}$$

$$v^2 = 1089$$

$$V = \sqrt{1089} = \cancel{46.2}\ 32\ ft/sec$$

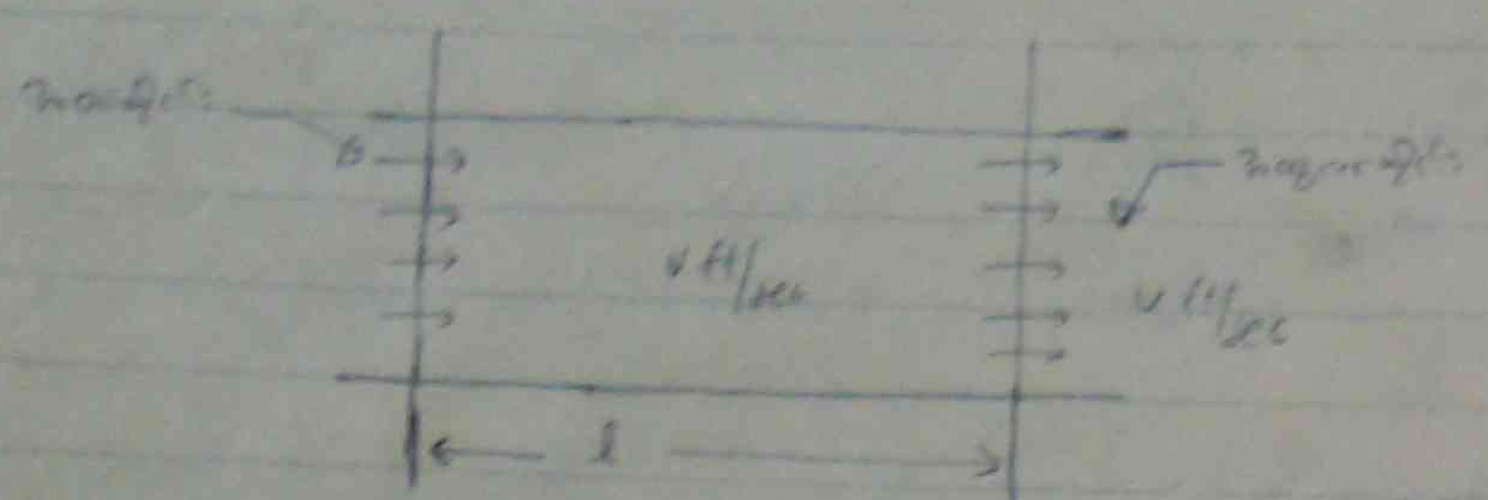
$$Q = A\times V = \frac{\pi}{4}\times\frac{1}{4}\times32.0 = 2\times3.14 = 6.28\ ft^3/sec$$

$v = 7.14\ ft/sec$

$Q = A \times v = \frac{\pi}{4} \times \frac{1}{4} \times 7.14 = 1.4\ ft^3/sec$

Transmission of Power Through Pipes

[illegible]



[illegible] = [illegible] head
[illegible] Total head [illegible] Total head

$H = H_1 + h_f$

$\therefore h_f = H - H_1$

[illegible] $w\ lb/sec = wQ = wav\ \ lb/sec$

[illegible] $HP = \frac{W H_1}{550}$

maximum power [illegible] $h_f = \frac{1}{3}H$ or $\frac{H}{3}$ [illegible]

Efficiency of transmission $= \frac{H_1}{H} \times 100$

$= \frac{H - h_f}{H} \times 100$

$= \left(1 - \frac{h_f}{H}\right) \times 100\ \%$

1981 Prome

Pb ④ Hydraulics machine [illegible] 3000 ft [illegible] machine [illegible] BHP [illegible] 60 HP [illegible] mechanical effy [illegible] 80%. [illegible] h_f [illegible] 751 lb/in² [illegible] Hydraulics machine [illegible] 680 lb/in² [illegible] $f = .008$ [illegible]

$Total\ HP = \frac{50}{.8} = 62.5\ HP$

$HP = \frac{wH_1}{550}$

$62.5 = \frac{w \times H_1}{550}$

$p = 751\ lb/\square''$

$H = \frac{P \times 144}{w} = \frac{751 \times 144}{62.5} = \frac{108144}{62.5} = 1730\ ft$

$H_1 = \frac{P_1 \times 144}{w} = \frac{680 \times 144}{62.5} = 1568\ ft$

$h_f = H - H_1 = 1730 - 1568 = 162\ ft$

$h_f = \frac{4flv^2}{2gd}$ — ①

$62.5 = \frac{w \times 1568}{550}$ $\quad w = \frac{62.5 \times 550}{1568} = \frac{34400}{1568} = 21.9\ lb$

$W = 21.9\ lb \quad W = wav$

$v = \frac{21.9}{62.5 \times \frac{\pi}{4} \times d^2}$

$v = \frac{21.9 \times 4}{62.5 \times \pi \times d^2} = \frac{87.6}{196.5\, d^2} = \frac{.445}{d^2}$

$v d^2 = .445$ — ②

$h_f = \frac{4flv^2}{2gd}$

$162 = \frac{4 \times .008 \times 3000 \times v^2}{2 \times 32 \times d}$

$162 = \frac{12000 \times .008\ v^2}{64\ d}$

$162 = \frac{96\ v^2}{64\ d}$

$d = \frac{96 v^2}{162 \times 64} = \frac{1.5 v^2}{162}$

$d^2 = \frac{2.25 \times v^4}{26400}$ — ③ [illegible] ② [illegible]

$v \times \frac{2.25 \times v^4}{26400} = .445$

$v^5 = \frac{.445 \times 26400}{2.25} = \frac{11750}{2.25}$

$v = (5225)^{.2} = 5.56\ ft/sec$

$5.56\ d^2 = .445 \quad d^2 = .0798 \quad d = .282\ ft$ [illegible]

5.5?

(5) [illegible] 1000 lb/in² [illegible] 100 HP [illegible] 10 psi [illegible] 10 [illegible] transmission [illegible] f = .006

Pressure drop = 10 × 10 = 100 psi

$\therefore P_2 = 1000 - 100 = 900\,psi$

$$H_2 = \frac{P_2 \times 144}{w} = \frac{900 \times 144}{62.5} = \frac{129600}{62.5} = 2070\,ft$$

$$H_f = H - H_2 = \frac{P_1 \times 144}{w} - \frac{P_2 \times 144}{w} = \frac{(P_1 - P_2)\times 144}{62.5}$$

$$H_f = \frac{100 \times 144}{62.5} = \frac{14400}{62.5} = 230.5\,ft$$

$$HP = \frac{W \times H_2}{550} \quad HP =$$

$$W = \frac{550 \times HP}{H_2} = \frac{550 \times 100}{2070} = \frac{55000}{2070} = 26.6\,lb/sec$$

$$W = wav =$$

$$26.6\,lb/sec = 62.5\,ft^3/sec \times v \times \frac{\pi}{4}(d)^2$$

$$26.6 = 62.5 \times .7854 \times v\, d^2$$

$$v = \frac{26.6}{62.5 \times .7854 \times d^2} = \frac{26.6}{49.2 d^2}$$

$$H_f = \frac{4flv^2}{2gd}$$ ft [illegible]

$$H_f = \frac{4flv^2}{2gd}$$

$$230.5 = \frac{4 \times .006 \times 10 \times 5280}{2 \times 32.2 \times d} \times \frac{26.6 \times 26.6}{49.2 \times 49.2\, d^4}$$

$$d^5 = \frac{.024 \times 52800 \times 707.5}{64.4 \times 230.5 \times 2410}$$

$$= \frac{1270 \times 707.2}{14850 \times 2410} = \frac{900000}{35800000} = .0251$$

$$d = .0251^{\frac{1}{5}} = .478\,ft$$

$$d = .478 \times 12 = 5.75''$$

$$\eta = \frac{H_2}{H_1} \times 100 = \frac{\frac{P_2 \times 144}{w}}{\frac{P_1 \times 144}{w}} \times 100$$

$$= \frac{P_2}{P_1} \times 100 = \frac{900}{1000} \times 100 = 90\%$$

(6) water turbine [illegible] 1750000 [illegible] 2 mile [illegible] Total head [illegible] 503 ft [illegible] f = .0075 η = 0.8 [illegible] Turbine [illegible]

$$lb/sec = \frac{1750000 \times 10}{3600} = \frac{17500000}{3600} = 4860\,lb$$

$$Hp = \frac{W \times H_2}{550} \qquad \frac{H_2}{H_1} = \eta = .8$$

$$H_2 = .8 \times 503 = 402.4\,ft$$

$$= \frac{4860 \times 402.4}{550}$$

$$= \frac{1958000}{550} = 3550\,HP$$

$$H_f = H_1 - H_2 = 503 - 402.4 = 100.6'$$

$$W = w \times a \times V$$

$$4860 = 62.5\,lb/ft^3 \times \frac{\pi}{4} d^2 \times V$$

$$d^2 v = \frac{4860}{62.5 \times .7854} = \frac{4860}{49.2} = 98.8$$

$$\therefore v = \frac{98.8}{d^2}$$

$$H_f = \frac{4flv^2}{2gd}$$

$$H_f = \frac{4fl}{2gd} \times v^2$$

$$100.6 = \frac{4 \times 2 \times 5280 \times .0075}{2 \times 32.2 \times d} \times \frac{98.8 \times 98.8}{d^4}$$

$$d^5 = \frac{8 \times 5280 \times .0075 \times 98.8 \times 98.8}{100.6 \times 64.4}$$

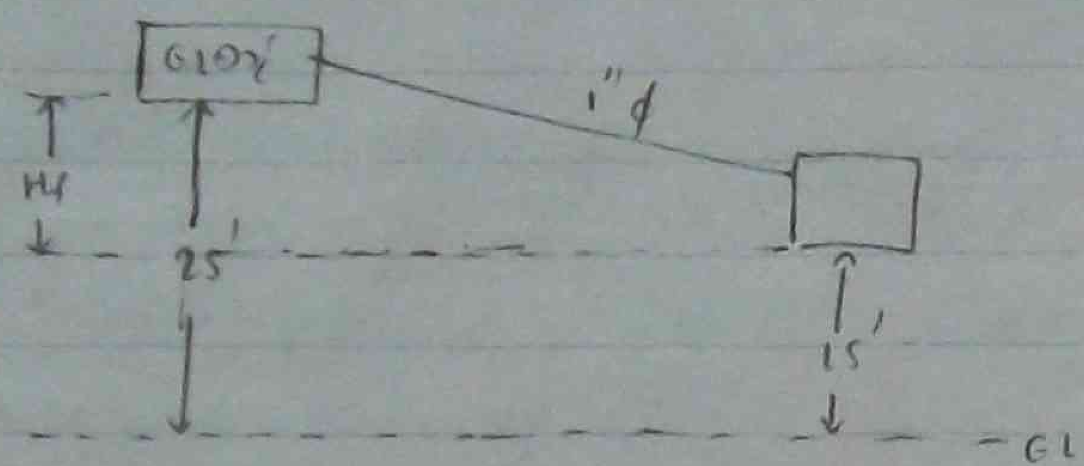
$$d^5 = \frac{42250 \times 9770 \times .0075}{6480}$$

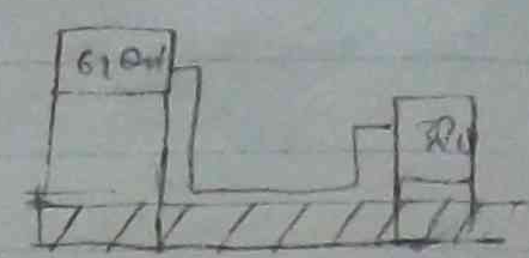
$$= \frac{412500000 \times .0075}{6480} = \frac{3090000}{6480} = 477$$

$$d = 477^{\frac{1}{5}} = 3.44\,ft$$

(7) [illegible] 1" ϕ [illegible] 150' [illegible] 15' [illegible] 1 min [illegible] gallon [illegible] ။

$f = .008$





Head loss = 25 − 15 = 10'   [illegible] = 150'

$$H_f = \frac{4flv^2}{2gd} + \frac{v^2}{2g}$$

$$10 = \frac{4 \times .008 \times 150 \times v^2}{2 \times 32.2 \times \frac{1}{12}} + \frac{v^2}{2 \times 32.2}$$

$$v^2 = \frac{10}{\left[\frac{4 \times .008 \times 150}{2 \times 32.2 \times \frac{1}{12}} + \frac{1}{64.4}\right]}$$

$$10 = v^2 \quad v = \sqrt{\frac{10}{.91055}} = \sqrt{10.98} = 3.31\ ft/sec$$

$$Q = A \times v = \frac{\pi}{4} \times \left(\frac{1}{12}\right)^2 \times 3.31\ ft^3/sec$$

$$= \frac{.7854 \times 3.31}{144}\ ft^3/sec$$

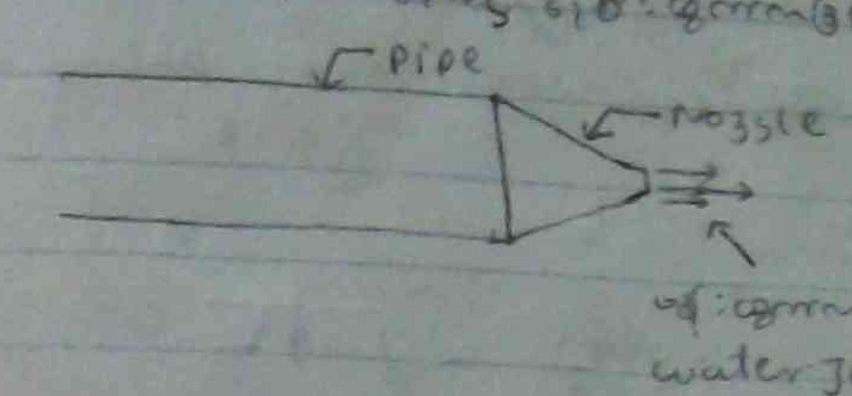
$$= \frac{2.6}{144}\ ft^3/sec$$

for 1 min = $\frac{2.6 \times 60}{144}\ ft^3/min = \frac{2.6 \times 60 \times 6.25}{144}$ gallon/min

$= 6.77$ gallons/min

Flow Through Nozzles

(Nozzle [illegible])



Pipe [illegible] = D ft

Nozzle [illegible] = d ft

Pipe [illegible] area = A ft^2

Nozzle [illegible] area = a ft^2

Pipe [illegible] = V ft/sec

Nozzle [illegible] = v ft/sec

$$Q = VA = va$$

$$v = V \times \frac{A}{a}$$

Nozzles

Nozzle [illegible] Pipe [illegible] ။

Nozzle [illegible] Turbine [illegible] ။ Nozzle [illegible] ။

Nozzle [illegible] water Jet [illegible] maximum power [illegible] head $h_f = \frac{1}{2}$ velocity head

$$\therefore h_f = \frac{1}{2}\frac{v^2}{2g}$$

[illegible] maximum power [illegible] $h_f = \frac{1}{3}$ Total head

$\therefore h_f = \frac{1}{3}H$ (Pipe [illegible])

[illegible] $h_f = \frac{4flV^2}{2gD}$

$$\therefore \frac{4flV^2}{2gD} = \frac{1}{2} \times \frac{v^2}{2g}$$

$$\frac{8fl}{D} = \frac{v^2}{V^2} \qquad [illegible]\ \frac{v}{V} = \frac{A}{a} \quad \therefore \frac{A^2}{a^2} = \frac{8fl}{D}$$

for max: power $\frac{A}{a} = \sqrt{\frac{8fl}{D}}$

water Jet HP $= \frac{Wv^2}{2g} \times \frac{1}{550}$

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}\frac{W}{g} \times v^2 = \frac{Wv^2}{2g}$$

$$W = \omega a v$$

$$\therefore HP = \frac{\omega a v^3}{2g \times 550}$$

(1) [illegible] 200 [illegible] head [illegible] 100 ft [illegible] $f = .01$, pipe [illegible] max. power [illegible] nozzle [illegible] Horse power [illegible] nozzle [illegible] Horse power [illegible]

Nozzle [illegible] = d [illegible]

$$\frac{A}{a} = \sqrt{\frac{8fL}{D}}$$

$$\frac{D^2}{d^2} = \sqrt{\frac{8\times.01\times 600}{.25}}$$

$$\frac{.25^2}{d^2} = \sqrt{\frac{48}{.25}}$$

$$\frac{.0625}{d^2} = \sqrt{192}$$

$$\frac{.0625}{d^2} = 13.8$$

$$d^2 = \frac{.0625}{13.8} = .004525$$

$$\therefore d = .0675' = .81'' \text{ or } .0675'$$

$$h_f = \frac{H}{3} = \frac{4fLV^2}{2gd}$$

$$\frac{100}{3} = \frac{4\times.01\times 200\times V^2}{2\times32.2\times.0250}$$

$$V^2 = \frac{100\times 64.4\times.0250}{12\times.01\times200\times3} = \frac{8.85\times64.4}{2400\times.01\times3} = \frac{400}{24\times3} = \frac{16.1}{72}$$

$$V^2 = 22.4' \qquad V = 4.73 \text{ ft/sec (pipe velocity)}$$

$$Hp = \qquad \frac{u}{V} = \frac{A}{a}$$

$$\frac{u}{4.73} = \frac{D^2}{d^2}$$

$$u = 4.73\times\frac{.25^2}{(.0675)^2} = \frac{4.73\times.0625}{.004525} = 4.73\times13.8 = 65.25 \text{ ft/sec}$$

$$Hp = \frac{wav^3}{2g\times550} = \frac{62.5\times\frac{\pi}{4}\times(.0675)^2\times65.25^3}{2\times32.2\times550}$$

$$Hp = \frac{62.5\times.7854\times.004525\times278500}{64.4\times550}$$

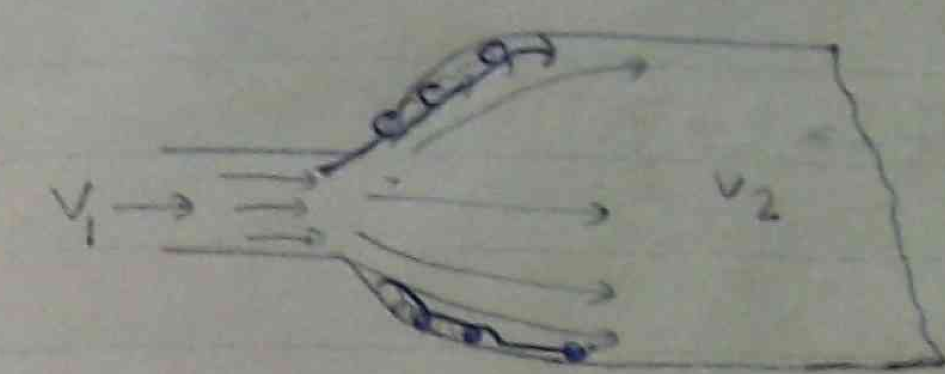
$$= \frac{49.2\times1262}{35400} = \frac{62000}{35400} = 1.75 \text{ HP}$$

Nozzle [illegible] HP $= \frac{wav^3}{2g\times550}$ = Hp

Turbine HP $= \frac{WH}{550}$

Loss of Head due to sudden Enlargement

([illegible])



$$h = \frac{(v_1 - v_2)^2}{2g} \text{ ft}$$

(1) [illegible] 6" [illegible] 1' [illegible] head [illegible] $4 \text{ ft}^3/\text{sec}$ [illegible]

$$d_1 = 6'' = \frac{1}{2}' \qquad a_1 = \frac{22}{7\times4}\times\left(\frac{1}{2}\right)^2 = \frac{\pi}{16} \text{ sq ft}$$

$$d_2 = 12'' = 1' \qquad a_2 = \frac{22}{7\times4}(1)^2 = \frac{\pi}{4} \text{ sq ft}$$

$$Q = a\times v$$

$$v_1 = \frac{Q}{a_1} = \frac{4\times16}{\pi} = \frac{64}{3.1416} = 20.38 \text{ ft/sec}$$

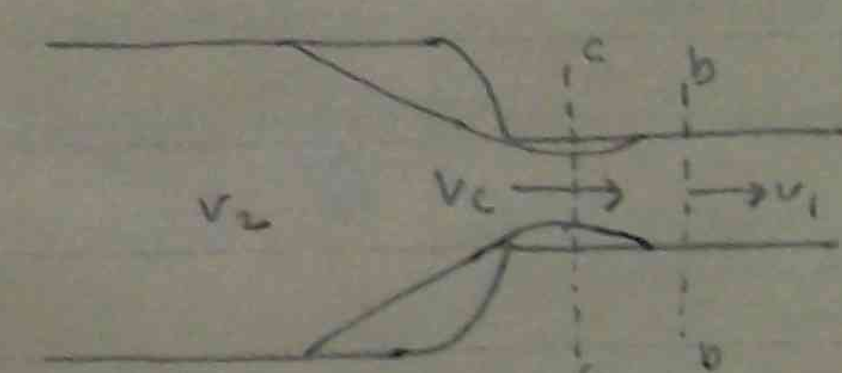
$$v_2 = \frac{Q}{a_2} = \frac{4\times4}{\pi} = \frac{16}{3.1416} = 5.1 \text{ ft/sec}$$

$$h = \frac{(v_1 - v_2)^2}{2g} = \frac{(20.38 - 5.1)^2}{64.4} = \frac{15.28^2}{64.4} = \frac{233.5}{64.4}$$

$$h = 3.63'$$

Loss of Head due to sudden contraction

([illegible])



$$h = \frac{(v_c - v_1)^2}{2g}$$

$$Q = v_c a_c = a_1 v_1$$

[illegible] $C_c = \frac{a_c}{a_1}$

$$\therefore v_c = \frac{v_1}{c_c}$$

$$\therefore h = \frac{\left(v/c_c - v_1\right)^2}{2g} = \frac{\left(\frac{1}{c_c} - 1\right)v_1^2}{2g}$$

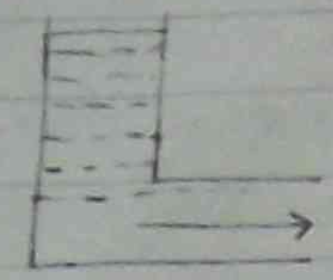
[illegible] $h = \frac{.5 v_1^2}{2g}$

$$\therefore h = \frac{1}{2}\times\frac{v_1^2}{2g} = \frac{.5v_1^2}{2g}$$

[illegible] head [illegible] $\frac{1}{2}\times\frac{v^2}{2g}$ [illegible]

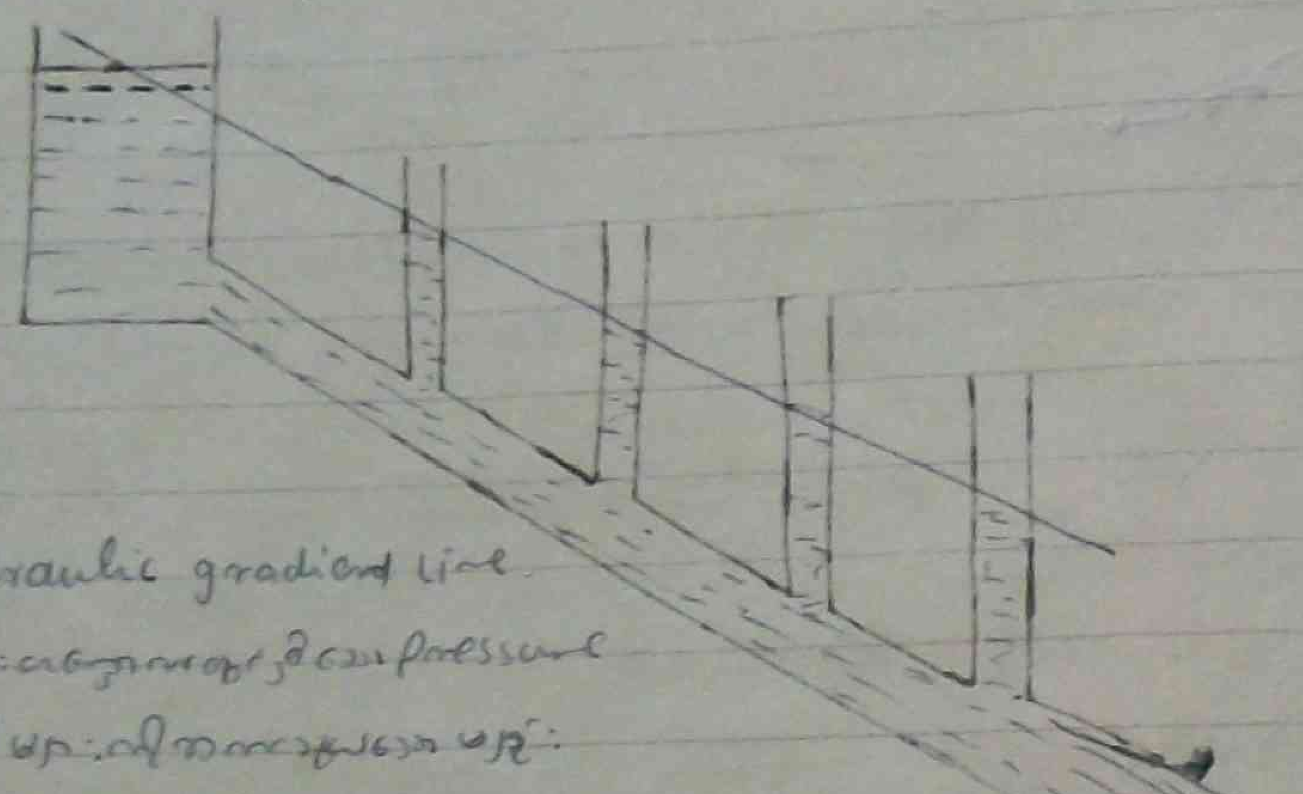
[illegible]

① f l



$h = \frac{1}{2} \times \frac{v^2}{2g}$

Hydraulic Gradient $\left[i = \frac{h_f}{l} \right]$



Hydraulic gradient line [illegible] Pressure head [illegible]

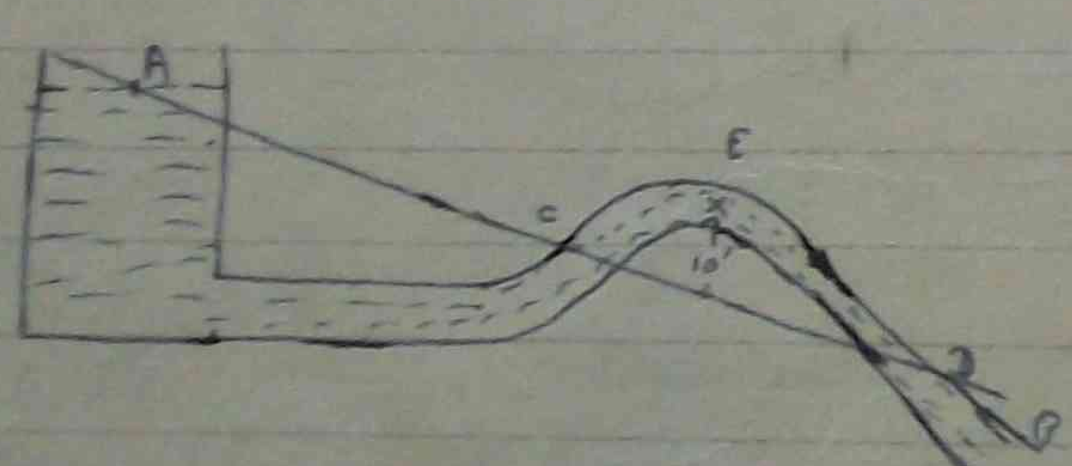
$\sin\theta = \frac{h_f}{l}$

[illegible] $\tan\theta$ =

$\sin\theta \simeq \tan\theta$

$\therefore \tan\theta = \frac{h_f}{l}$ $\tan\theta = i$ slope

$$\therefore \boxed{i = \frac{h_f}{l}}$$



[illegible] head [illegible] Pressure head [illegible]

[illegible] Hydraulic gradient [illegible] pressure head [illegible]

[illegible] pressure head [illegible]

[illegible] Hydraulic gradient line [illegible]

[illegible] Hydraulic gradient [illegible] h [illegible] slope [illegible] slope = $\frac{h_f}{L}$ [illegible] head [illegible] L [illegible] Hydraulic gradient [illegible]

[illegible] pressure head [illegible] pressure [illegible] Pressure head [illegible] Hydraulic gradient [illegible] Pressure [illegible] pressure [illegible]

[illegible] Pressure [illegible] pressure [illegible] Pressure [illegible] pressure [illegible]

[illegible] E [illegible] Hydraulic gradient [illegible] Pressure [illegible] E [illegible] Hydraulic gradient [illegible] 10' [illegible] 15' [illegible] Hydraulic gradient [illegible] 10' [illegible]

Chezy's Formula

$$h_f = \frac{f' L v^2}{m w}$$

pipe line [illegible] slope or hydraulic gradient $= i = \frac{h_f}{l}$

$$\therefore i = \frac{f' v^2}{m w}$$

$$\therefore v = \sqrt{\frac{i m w}{f'}}$$

let $c = \sqrt{\frac{w}{f'}}$ $\therefore v = c\sqrt{m i}$

m = hydraulic mean depth $= \frac{A}{P} = \frac{\text{Area}}{\text{wetted perimeter}} = \frac{\text{Area}}{[illegible]} =$

$= \frac{[illegible]\ \text{area}}{[illegible]} = \frac{\pi/4\, d^2}{\pi d} = \frac{d}{4}$ [illegible]

c = Chezy's constant

1 Pb① [illegible] 8" [illegible] 150' [illegible] 8 ft/sec [illegible] Che[illegible] constant [illegible] 106 [illegible] head [illegible] (pipe)

$V = c\sqrt{mi}$ $v = 8\ ft/sec$ $m = \frac{d}{4} = \frac{8}{12\times 4} = \frac{1}{6}$

$c = 106$

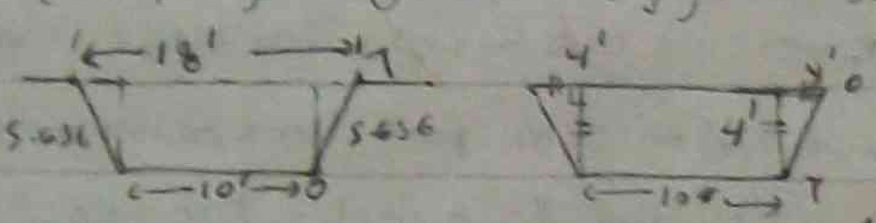
$8 = 106\sqrt{\frac{1}{6}\times i}$

$\frac{8}{106}\times\frac{8}{106}\times 6 = i$

$h_f = i\times L = \frac{8}{106}\times\frac{8}{106}\times 6\times 150$

$h_f = \frac{64\times 900}{11250} = \frac{57600}{11250} = 5.12\ ft$

Pb② [illegible] 10' [illegible] 1:1 [illegible] slope [illegible] 3' [illegible] Che[illegible] constant [illegible] 95 [illegible]



$V = c\sqrt{mi}$

[illegible] $= 18'$

Area $= (18+10)\times\frac{1}{2}\times 4 = 56\ ft^2$ $\sqrt{4^2+4^2} = 5.656$

Slope $= \frac{3}{5280}$ ($3\ ft/mile$) $P = 10+5.656\times 2 = 21.312$ ([illegible])

$\therefore i = \frac{3}{5280}$

$m = \frac{A}{P} = \frac{56}{21.312} = 2.63$

$V = 95\sqrt{2.63\times\frac{3}{5280}}$

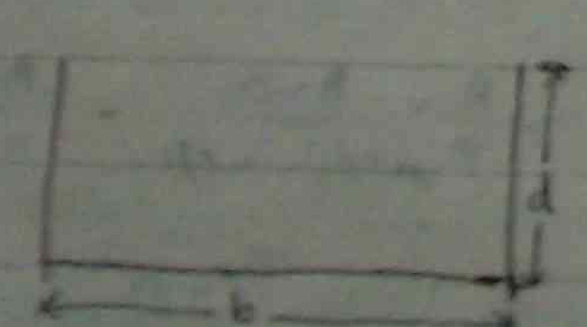
$v = 95\sqrt{\frac{7.9}{5280}} = 95\sqrt{.001495} = 95\times .0385 = 3.66\ ft/sec$

$Q = Av = 56\times 3.66 = 206\ ft^3/sec$

Pb③ [illegible] 10' slope [illegible] 1000 [illegible], $c = 105$ [illegible]

[illegible]

most Economical dram



$b = 10'$ $d = 5'$

$P = 10+5+5 = 20'\ ft$

[illegible] $b = 2d$ $m = \frac{A}{P} = \frac{10\times 5}{20} = 2.5$

$i = \frac{1}{1000}$ $V = c\sqrt{mi}$

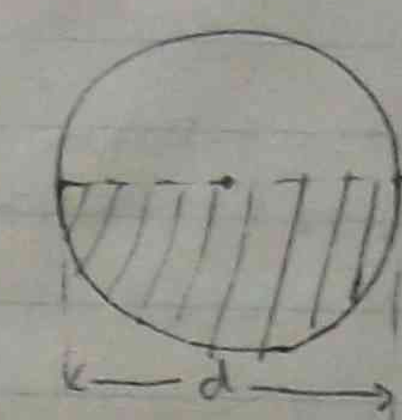
$V = 105\sqrt{2.5\times\frac{1}{1000}} = 105\sqrt{.0025} = 105\times .05 = 5.25\ ft/sec$

$Q = A\times V$

$= 50\times 5.25 = 262.5\ ft^3/sec$

Pb④ 1 [illegible] 2500 [illegible] gallon 40 [illegible] 7% [illegible] 24 hr [illegible] 1" [illegible] $c = 130$ Slope $= \frac{1}{3000}$

([illegible])



$V = c\sqrt{mi}$ $i = \frac{1}{3000}$ $c = 130$

[illegible] $= \frac{2500\times 20\times 40\times 10}{62.5}\ ft^3/day$

[illegible] $= \frac{7}{100}\times\frac{2500\times 20\times 40\times 10}{62.5}\ ft^3/hr$

$= \frac{7}{100}\times\frac{2500\times 20\times 40\times 10}{62.5\times 3600}\ ft^3/sec$

$\therefore$ [illegible] $= \frac{175\times 80}{2250} = \frac{14000}{2250} = 6.225\ ft^3/sec$

[illegible] 24 hr [illegible] $= \frac{1}{12}\ ft\times 2500$ acre

$= \frac{1}{12}\ ft\times 2500\times 4840\times 9$

$= \frac{1}{12}\times 2500\times 43600 = \frac{109000,000}{12\times 24\times 3600}\ ft^3/sec$

$= \frac{109000,000}{288\times 3600} = \frac{109000,000}{1036800} = 105\ ft^3/sec$

$\therefore$ [illegible] 1 sec [illegible] $= 105 + 6.225 = 111.225\ ft^3/sec$

$Q = A\times V$

$111.225 = \frac{\pi}{4}d^2\times\frac{1}{2}\times V$

$111.225 = \frac{.7854}{2}\times d^2\times V$

$d^2 v = \frac{111.225\times 2}{.7854} = \frac{222.5}{.7854} = 283$ ——①

$V = c\sqrt{mi}$ $m = \frac{\frac{\pi}{4}\times d^2\times\frac{1}{2}}{\frac{\pi d}{2}}$

$V = 130\sqrt{\frac{1}{3000}\times\frac{d}{4}}$ ——②

$V = 130\frac{\sqrt{d}}{\sqrt{12000}}$ ——② $= \frac{\pi d^2}{4\times 2}\times\frac{2}{\pi d} = \frac{d}{4}$

① [illegible] $d^2\times\frac{130\times d^{.5}}{\sqrt{12000}} = 283$ $\therefore d^{2.5} = \frac{283\times 109.55}{130} = \frac{31000}{130} = 238.1$

$\therefore d = 238.1^{\frac{1}{2.5}} = 8.9\ ft$

[illegible] $F = \frac{W}{g} V \sin\theta$

[illegible] (normal force) $F = \frac{\omega a v^2}{g} \sin\theta$ lbs

(1) [illegible] water Jet [illegible] (A) water Jet [illegible] (B) water Jet [illegible] normal force [illegible]

[illegible] water Jet [illegible]

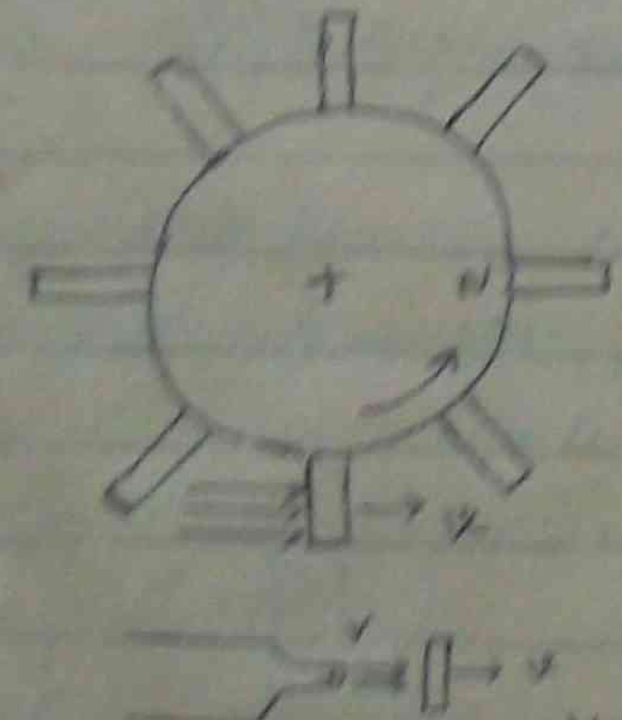
$$F = \frac{\omega a v^2}{g} = \frac{62.5 \times \frac{\pi}{4} \times \left(\frac{2}{12}\right)^2 \times 100{,}00}{32.2}$$

$$= \frac{62.5 \times .7854 \times 4 \times 100{,}00}{144 \times 32.2}$$

$$= \frac{49.1 \times 400{,}00}{4640} = \frac{1964000}{4640} = 422 \text{ lb}$$

$$F = 422 \times \sin 60 = 422 \times .866 = 366 \text{ lb}$$

[illegible]



$v - u$ = Relative velocity [illegible]

[illegible] water Jet [illegible] water Jet [illegible] Relative velocity [illegible] $V - u$ [illegible] water Jet [illegible] 1 sec [illegible] ft [illegible]

[illegible] water Jet [illegible]

[illegible]

[illegible]

[illegible] water Jet [illegible]

[illegible] water Jet [illegible] $(v-u)$ ft/sec

[illegible] $= \frac{w}{g}(v-u)$ lbs

$$F = \frac{\omega a V (V-u)}{g}$$

work done on the plate $= F u$ ft-lb/sec

water Jet [illegible] $= \frac{W}{g}(v-u) \times u$ ft-lb/sec

[illegible] $= \frac{(v-u) \times u}{g}$ ft-lb/sec $\cdot$ 1/lb

water Jet [illegible] $= \frac{1}{2} \times \frac{w}{g} \times v^2$ ft-lb/sec $\times$ 1/lb

$\therefore$ [illegible] $= \frac{v^2}{2g}$ ft-lb/sec $\times$ 1/lb

efficiency of plate $= \frac{(v-u)\,u/g}{v^2/2g} \times 100$

$$\therefore \eta\,\% = \frac{2(v-u) \times u}{v^2} \times 100$$

max: effy: [illegible] $u = \frac{v}{2}$ [illegible]

$\therefore$ Maximum efficiency $= 2\frac{\left(v - \frac{v}{2}\right) \times \frac{v}{2}}{v^2} \times 100$ [illegible]

$$\therefore \eta = 50\,\%$$

(1) [illegible] [illegible] $= \frac{\omega a (v-u)^2}{g} \sin\theta$

(2) [illegible] [illegible] $= \frac{\omega a v (v-u)}{g} \sin\theta$

(1) [illegible] 2" [illegible] water Jet [illegible] 60 ft/sec [illegible] Jet [illegible] water Jet [illegible] 20 ft/sec [illegible]

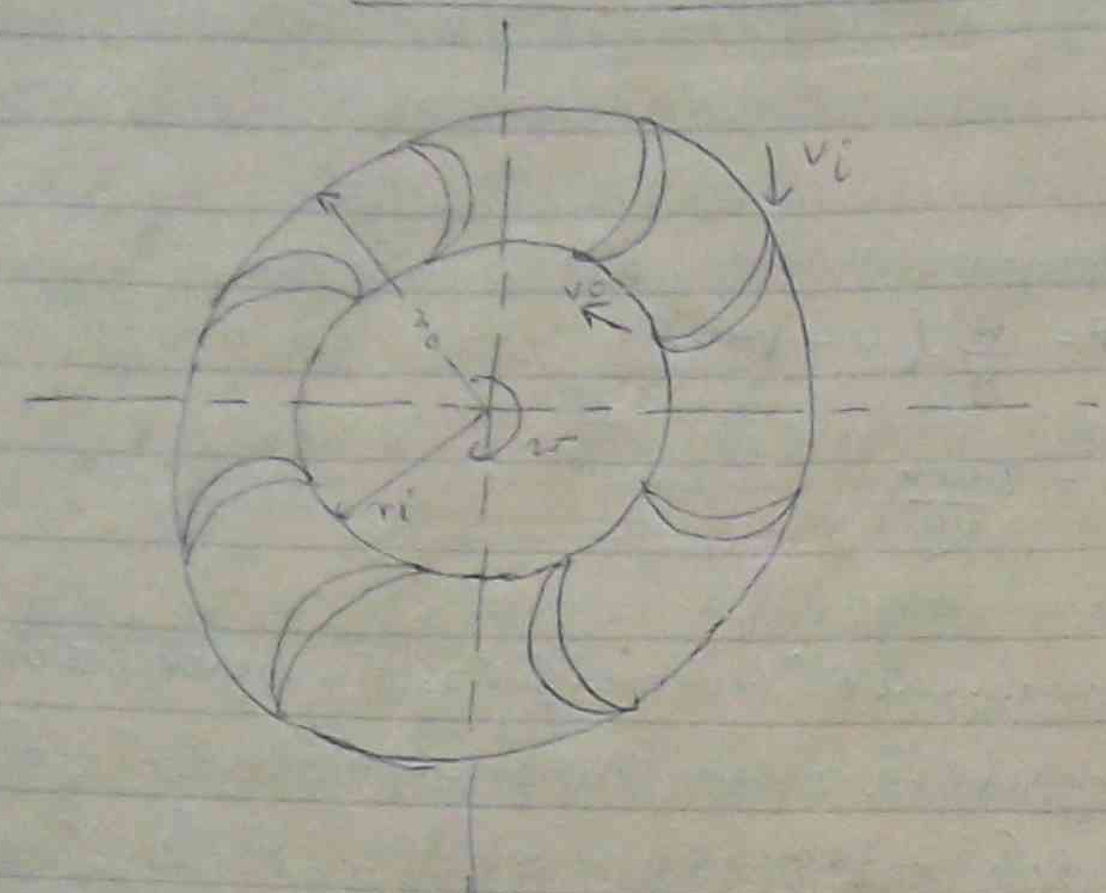
$$F = \frac{\omega a v^2}{g} = \frac{62.5 \times \frac{\pi}{4}\left(\frac{2}{12}\right)^2 \times 3600}{32} = \frac{49.1 \times 4 \times 3600}{32 \times 144}$$

$$= \frac{49.1 \times 14400}{32 \times 144} = \frac{49.1 \times 100}{32} = \frac{4910}{32} = 153.5 \text{ lb}$$

$$F = \frac{\omega a (v-u) \times v}{g} = \frac{62.5 \times \frac{\pi}{4}\left(\frac{2}{12}\right)^2 \times (60-20) \times 60}{32}$$

$$= \frac{49.1 \times 4 \times 40 \times 60}{32 \times 144} = \frac{196.5 \times 2400}{4610} = \frac{472000}{4610} = 102.3 \text{ lb}$$

Flow over Radial vane



[illegible] wheel [illegible] radial [illegible]

r_i = [illegible] Inward flow [illegible] Turbine [illegible] curve vane [illegible] outlet [illegible]
outward flow Turbine [illegible] curve vane [illegible] inlet [illegible]

r_o = [illegible] Inward flow Turbine [illegible] curve vane [illegible] Inlet [illegible]
outward flow Turbine [illegible] curved vane [illegible] out let [illegible]

ω = wheel [illegible] angular velocity , radian/sec

v_I = curved vane [illegible] tangential velocity

Inward flow ([illegible]) [illegible] $v_i = r_o\omega$ ft/sec

out ward flow ([illegible]) [illegible] $v_i = r_i\omega$ ft/sec

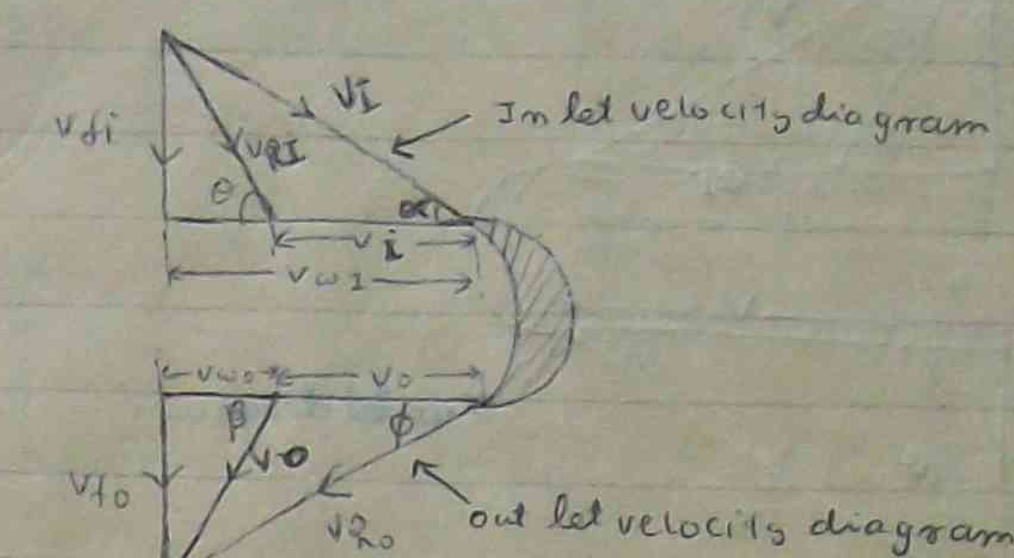
v_o = curved vane [illegible] Tangential velocity

Inward flow Turbine $\longrightarrow$ $v_o = r_i\omega$

outward flow Turbine $\longrightarrow$ $v_o = r_o\omega$

Velocity diagram for Inward flow Turbine

([illegible] Turbine [illegible] Inlet velocity diagram)



V_I = water jet [illegible]

v_i = [illegible]

[illegible] Radial curve vane [illegible] (work done) [illegible] efficiency [illegible]

Radial curve vane [illegible] water Jet [illegible] Tangential momentum $= \frac{V_{wI}}{g}$

$\therefore$ vane [illegible] moment of momentum $= \frac{V_{wI}\, r_o}{g}$

vane [illegible] moment of momentum $= \frac{V_{wo}\, r_i}{g}$

$\therefore$ Charge of moment of momentum [illegible] Torque $= \left[\frac{V_{wI}\, r_o}{g} - \frac{-V_{wo}\, r_i}{g}\right]$ ft-lb/lb of water

$\therefore$ [illegible] $= \left[\frac{V_{wI}\, r_o}{g} + \frac{V_{wo}\, r_I}{g}\right]\omega$ ft-lb/sec / lb of water

[illegible] $v_I = \omega r_o$

$v_o = \omega r_i$

$\therefore$ [illegible] $= \frac{V_{wI} v_i + V_{wo} v_o}{g}$ ft-lb/sec / lb of water

$$\eta\,\% = \frac{(V_{wI} v_i + V_{wo} v_o)/g}{V_I^2/2g} \times 100$$

$$= \frac{2\,(V_{wI} v_i + V_{wo} V_o)}{V_I^2} \times 100$$

Radial flow [illegible] $v_I \neq v_o$

$V_{RI} \neq V_{Ro}$

143/Prome

① radial Blade [illegible] $4'$ [illegible] $2'$ [illegible] water Jet [illegible] 100 ft/sec [illegible] Tangent [illegible] 30° [illegible]
Blade [illegible] 40° [illegible] 35° [illegible] Blade [illegible] velocity of flow 14 ft/sec [illegible] efficiency [illegible]
([illegible] Turbine [illegible])

Inlet diagram

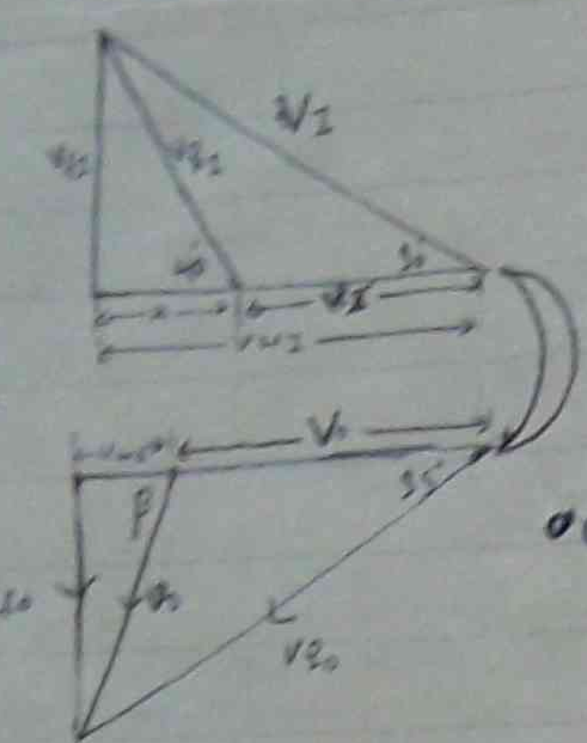
$r_i = \frac{2}{2} = 1'$

$r_o = \frac{4}{2} = 2'$

$V_I = 100\ ft/sec$

$\alpha = 30°$

$\phi = 35°$



Outlet diagram

$V_{wI} = V_I \cos 30 = 100 \times .866 = 86.6\ ft/sec$

$V_{fI} = V_I \sin 30$

$= 100 \times \frac{1}{2} = 50\ ft/sec$

$x = \frac{V_{fI}}{\tan\phi} = \frac{50}{\tan\phi} = 59.6\ ft/sec$

$v_i = V_{wI} - x = (86.6 - 59.6) = 27\ ft/sec$

$v_i = \omega r_o$

$\omega = \frac{v_i}{r_o} = \frac{27}{2} = 13.5\ radian/sec$

$N = \frac{13.5 \times 60}{2\pi} = \frac{810}{6.28} = 129\ r.p.m$

$V_o = \omega r_i = 1 \times 13.5 = 13.5\ ft/sec$

$V_{fo} = 14\ ft/sec$

$\tan\phi = \frac{V_{fo}}{V_{wo}+v_o}$ $\therefore V_{wo} + v_o = \frac{V_{fo}}{\tan\phi} = \frac{14}{\tan 30} = 20\ ft/sec$

$V_{wo} = 20 - v_i = 20 - 13.5 = 6.5\ ft/sec$

WD / lb of water $= \frac{V_{wI} v_i + V_{wo} v_o}{g}$

$= \frac{(86.6 \times 27) + (6.5 \times 13.5)}{32}$

$= 75.4$ ft-lb / lb of water/sec

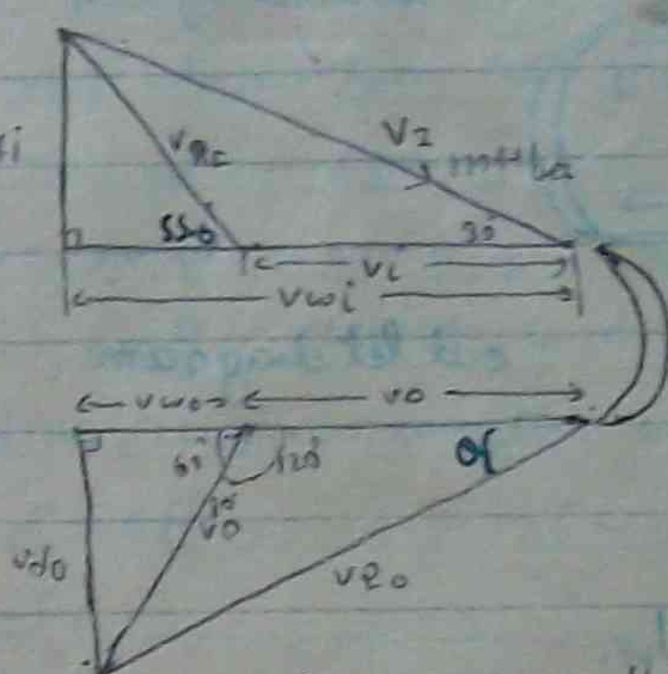
$\eta\% = \frac{75.4}{\frac{100^2}{64}} \times 100 = 48.25\%$

Blade [illegible] $\eta = \frac{2g\,WD}{V_I^2} \times 100$

Moving blade fixed blade [illegible] $\eta_{Hyd} = \frac{H - \frac{V_o^2}{2g}}{H}$ or $\eta = \frac{WD}{WD + \frac{V_o^2}{2g}}$

---

(2) [illegible] Turbine [illegible] Radial blade [illegible] water jet [illegible] 120 ft/sec [illegible] blade [illegible] 10 ft/sec [illegible] Tangent [illegible] 150° [illegible] blade [illegible] r.p.m [illegible] 300 [illegible] curve blade [illegible] Effy [illegible]



$r_o = \frac{4}{2} = 2'$

$r_i = \frac{2}{2} = 1'$

$V_{wI} = 120 \cos 30 = 120 \times .866 = 104\ ft/sec$

$V_{wo} = 10 \cos 60 = 5\ ft/sec$

$\omega = \frac{2\pi N}{60}$ $v_i = \omega r_o$ $V_o = \omega r_i$

$v_i = \frac{6.28 \times 200}{6} = 62.86\ ft/sec$ $V_o = 31.40 \times 1 = \cancel{62.8}\ ft/sec$ 31.4

WD / lb of water $= \frac{V_{wI} v_i + V_{wo} v_o}{g}$

$= \frac{104 \times 62.86 + 5 \times 31.4}{32} = \frac{6540 + 31.405}{32} = \frac{6556.4}{32}$

$= 208\ lb$

$Eff'y = 2g\frac{WD}{V_I^2} = \frac{2 \times 32 \times 208}{14400} = \frac{64 \times 208}{14400} = 93\%$

$x = V_{wi} - v_i = 104 - 62.8 = 41.2$

$\cot\theta = \frac{41.2}{60} = .685$ $\therefore \theta = 55.0°$

$V_{fo} = V_o \sin 60 = 10 \times .866 = 8.66\ ft/sec$

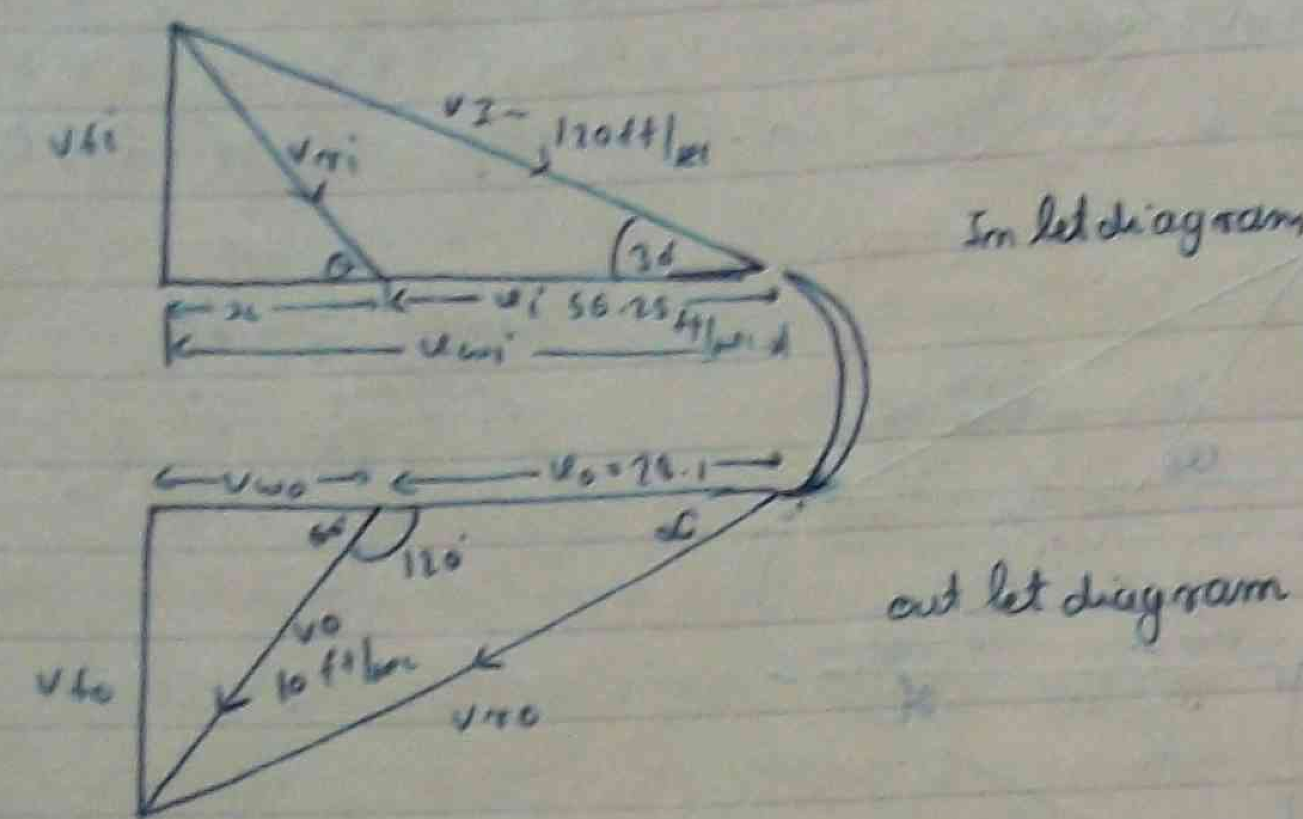
$\tan\theta = \frac{8.66}{31.4 + 5} = \frac{8.66}{36.4} = .2383$

$\therefore \theta = \tan^{-1} .2383 = 13.4°$ Ans

(3) Radial curved vane [illegible] Turbine [illegible] 1.5' [illegible] water jet [illegible] 120 ft/sec [illegible] Nozzle [illegible] 30° [illegible] curved vane [illegible] 10 ft/sec [illegible] angle tangent [illegible] 120° [illegible] Turbine r.p.m 360 [illegible] curved vane [illegible]

$v_i = \omega r_o = 37.5 \times 1.5 = 56.25\ ft/_{sec}$ $\omega = \frac{2\pi N}{60} = \frac{2 \times 3.14 \times 360}{60} = 6.28 \times 6 = 37.5$

$v_o = \omega r_i = 37.5 \times .75 = 28.125\ ft/_{sec}$



$V_{fi} = 120 \sin 30° = 120 \times \frac{1}{2} = 60\ ft/_{sec}$

$V_{wi} = 120 \cos 30° = 120 \times .866 = 104\ ft/_{sec}$

$\therefore x = 104 - 56.25 = 47.75\ ft/_{sec}$

$\therefore \tan\theta = \frac{60}{47.75} = 1.255 \qquad \therefore \theta = \tan^{-1} 1.255 = 51.5°$

$V_{wo} = 10 \cos 60 = 10 \times \frac{1}{2} = 5\ ft/_{sec}$

$V_{fo} = 10 \sin 60 = 10 \times .866 = 8.66\ ft/_{sec}$

$v_o + V_{wo} = 5 + 28.1 = 33.1\ ft/_{sec}$

$\tan\alpha = \frac{8.66}{33.1} = .261 \qquad \therefore \alpha = \tan^{-1} .261 = 14.65°$

$$W_D = \frac{V_{wi} v_i + V_{wo} v_o}{g}$$

$$= \frac{104 \times 56.25 + 5 \times 28.1}{32}$$

$$= \frac{5850 + 140.5}{32} = \frac{5990.5}{32} = 187\ ft\text{-}lb/lb \text{ of water} \quad \leftarrow \text{Ans}$$

** ① HP = act. eff % × $\frac{H}{550}$ × Total weight ⟶ to cal. Find H

② HP = [illegible] % × $\frac{V_{wi} v_i + V_{wo} v_o}{g \times 550}$ × Total weight ⟶ To find $V_{wi} v_i$

HP = [illegible] % × $\frac{H - v_o^2/2g}{g \times 550}$ × Total weight

$\frac{V_{wi} v_i}{g} = H - \frac{v_o^2}{2g}$ to find V_{wi}

Turbines

(1) Reaction Turbine or Pressure Turbines.

(2) Impulse Turbines or velocity Turbines.

Turbines [illegible] – (1) reaction Turbine – reaction Turbine [illegible]

[illegible] Pressure [illegible] Turbine [illegible] Turbine [illegible] Turbine [illegible] Turbine [illegible] velocity head [illegible] reaction Turbine [illegible] head [illegible]

H = Turbine [illegible] Head (ft)

V_o = Turbine [illegible] (ft/sec)

∴ Turbine [illegible] = $\left(H - \frac{v_o^2}{2g}\right)$ ft-lb/sec

$$H \neq \frac{V_I^2}{2g}$$

(2) Impulse Turbine

Impulse Turbine [illegible] Turbine [illegible] Nozzle [illegible] Turbine [illegible] Turbine [illegible] water jet [illegible] head [illegible] velocity head [illegible] Turbine [illegible] water jet [illegible] Turbine [illegible] head [illegible] head [illegible] Turbine [illegible]

$$H = \frac{V_I^2}{2g}$$

V_I = Nozzle [illegible] Turbine [illegible] (ft/sec)

V_o = Turbine [illegible] (ft/sec)

Turbine [illegible] = $\left(\frac{V_I^2}{2g} - \frac{v_o^2}{2g}\right)$ ft-lb/sec

(1) Radial flow Turbine.
(a) Inward
(b) outward
(2) Axial flow Turbine.
(3) mixed flow turbine

[illegible] reactional Impulse Turbine [illegible]

[illegible] (1) Radial flow Turbine

Turbine [illegible] (a) Inward radial flow Turbine [illegible] (b) outward radial flow Turbine [illegible]

(2) Axial flow Turbine

Turbine [illegible] Axis [illegible] Turbine [illegible] axial flow Turbine [illegible]

(3) mixed flow Turbine

[illegible] Turbine [illegible] Axial flow [illegible] radial flow [illegible] Turbine [illegible] mixed flow Turbine [illegible]

MODERN TURBINES

(1) Low head

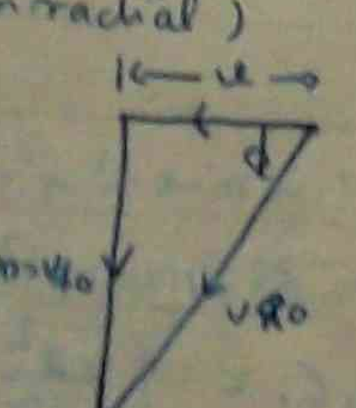
Kaplan Turbine (Axial flow reaction Turbine)

Propeller Type

(2) medium heads (Francis turbine) [Inward flow Reaction turbine]

(3) High head pelton wheels [Axial flow impulse Turbine]

Reaction Turbines – curved vane [illegible] water Jet [illegible] (discharge in radial)



out let velocity diagram

$\beta \simeq 90^\circ$

$V_{w0} = 0$

H [illegible] $\frac{V_0^2}{2g}$ [illegible]

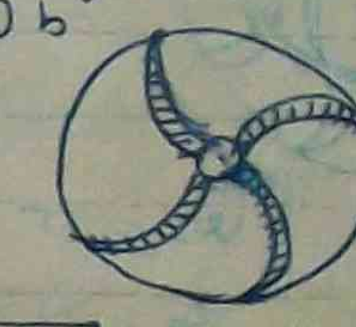
efficiency $\eta = \frac{H - \frac{V_0^2}{2g}}{H} \times 100$

Radial area of flow out inlet $= (2\pi r - Nt)\,b$

where N = number of vanes

t = vane [illegible]

b = vane [illegible]



Radial area of flow out inlet $= \boxed{A_I = K\,2\pi r b}$

$K < 1$

K = factor of area of vane – [illegible] $= 1$

$\therefore$ Turbine [illegible] $= Q_I$

$\therefore Q_I = A_I V_{fI} = (K 2\pi r b) V_{fI}$ ft^3/sec

[illegible] $\frac{Q_I}{Q_0} = \frac{A_I V_{fI}}{A_0 V_{f0}} = 1$

$\therefore A_I V_{fI} = A_0 V_{f0}$

[illegible]

$K 2\pi r_0 b V_{fI} = K 2\pi r_i b V_{f0}$

$r_0 V_{fI} = r_i V_{f0}$

$$\boxed{\frac{V_{fI}}{V_{f0}} = \frac{r_i}{r_0}}$$

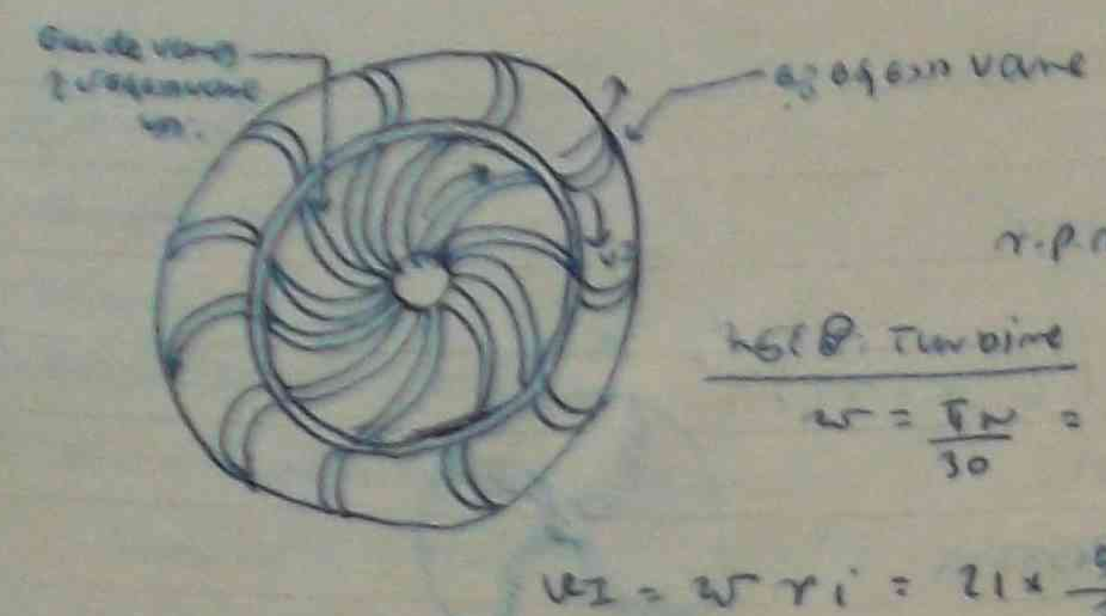
[illegible]

$K 2\pi r_i b V_{fI} = K 2\pi r_0 b V_{f0}$

$r_i V_{fI} = r_0 V_{f0}$

$$\boxed{\frac{V_{fI}}{V_{f0}} = \frac{r_0}{r_I}}$$

(4) outward flow Reaction Turbine [illegible] r.p.m = 200 vane [illegible] breadth 9" [illegible] curve vane [illegible] out let [illegible] Total head [illegible] 120 ft [illegible] 200 ft^3/sec [illegible] Hydraulic efficiency 90% [illegible] curve vane [illegible] guide blade [illegible]



r.p.m = 200

[illegible] Turbine

$$\omega = \frac{\pi N}{30} = \frac{\pi \times 200}{300} = 21 \text{ radian/sec}$$

$$u_I = \omega r_i = 21 \times \frac{5}{2} \text{ ft} = 52.5 \text{ ft/sec}$$

$$u_o = \omega r_o = 21 \times \frac{6}{2} = 63 \text{ ft/sec}$$

$$\eta = \frac{H - \frac{V_o^2}{2g}}{H} \times 100$$

$$\therefore 90 = \frac{120 - \frac{V_o^2}{2g}}{120} \times 100$$

$$\therefore \frac{V_o^2}{2g} = 120 - 120 \times .9 = 12$$

$$\therefore V_o = \sqrt{12 \times 2 \times 32} = \sqrt{768} = 27.7 \text{ ft/sec}$$

$$Q = V_{fI} \times A_I$$

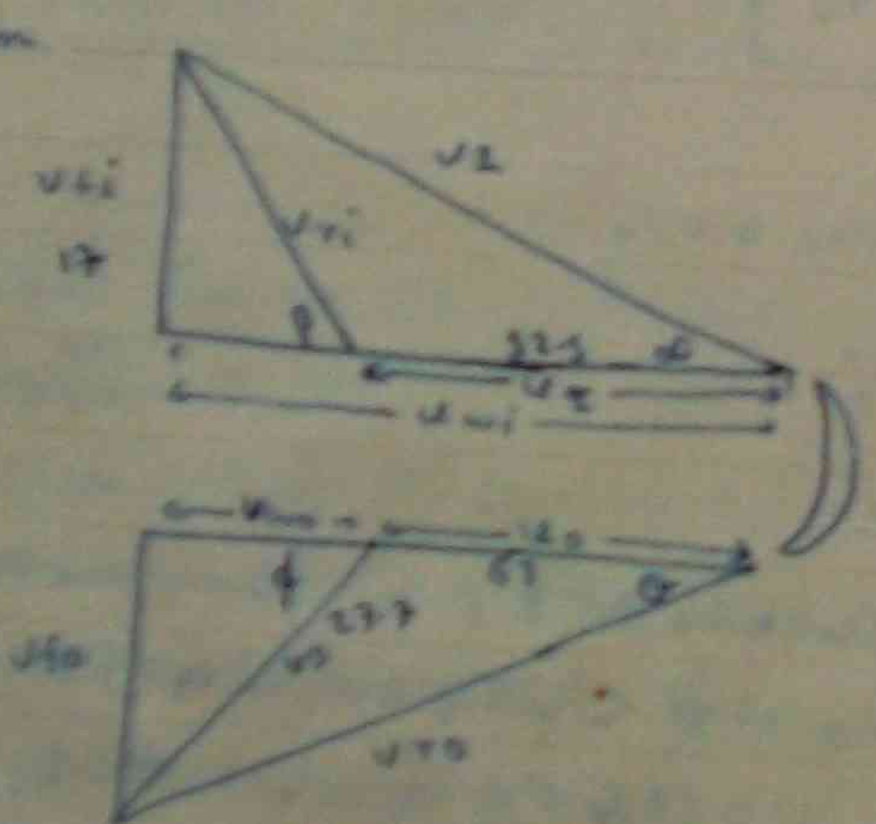
$$A_I = 2\pi k r_I b$$

$$200 = V_{fI}(2\pi k r_i)b$$

$$200 = V_{fI}\left(2 \times 3.14 \times 1 \times \frac{5}{2}\right) \times \frac{9}{12}$$

$$V_{fI} = \frac{200}{15.7 \times \frac{9}{12}} = \frac{2400}{141.3} = 17 \text{ ft/sec}$$

Inlet diagram



[illegible] Turbine [illegible]

$$\frac{V_{fI}}{V_{fo}} = \frac{r_o}{r_i}$$

$$\therefore V_{fo} = \frac{V_{fI} r_i}{r_o} = \frac{17 \times 2.5}{3} = \frac{42.5}{3} = 14.15 \text{ ft/sec}$$

$$V_{wo} = \sqrt{V_o^2 - V_{fo}^2} = \sqrt{27.7^2 - 14.15^2} = \sqrt{768 - 200} = \sqrt{568} = 23.82 \text{ ft/sec}$$

$$\sin\phi = \frac{14.15}{27.7} = .512 \quad \therefore \phi = 30.7^\circ$$

$$\tan\theta = \frac{14.15}{23.82 + 63} = \frac{14.15}{86.82} = .163 \quad \therefore \theta = \tan^{-1} .163 = 9.29^\circ$$

V_{wI} ရှာရန်

[illegible] $= \dfrac{V_{wI} u_I + V_{wo} u_o}{g}$

$$H - \frac{V_o^2}{2g} = \frac{V_{wI} u_I + V_{wo} u_o}{g}$$

$$120 - \frac{27.7^2}{64} = \frac{V_{wI} \times 52.5 + 23.82 \times 63}{32}$$

$$\frac{V_{wI} \times 52.5 + 1502}{32} = 120 - \frac{768}{64}$$

$$1.642 V_{wI} + 47 = 120 - 12$$

$$1.642 V_{wI} = 120 - 59 = 61$$

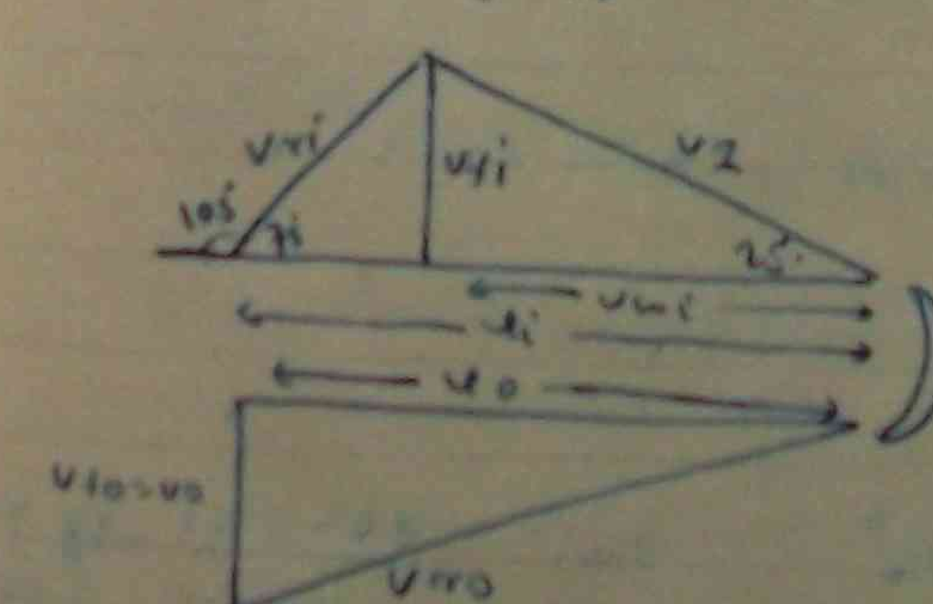
$$V_{wI} = \frac{61}{1.642} = 37.2 \text{ ft/sec}$$

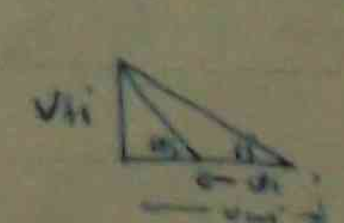
$$\tan\alpha = \frac{17}{37.2} = .457 \quad \therefore \alpha = \tan^{-1} .457 = 24.35^\circ$$

$$\tan\beta = \frac{17}{37.2 - 52.5} = -\frac{17}{15.3} = -1.11$$

$$\beta = (180 - 48) = 132^\circ$$

(5) Low head inward flow reaction Turbine တစ်ခု၏ guide blade ၏ [illegible] Turbine blade ၏ tangent နှင့် 25° [illegible] Turbine wheel [illegible] blade ၏ inlet angle သည် 105° [illegible] discharge သည် radial [illegible] velocity of flow constant [illegible] head သည် 15' [illegible] velocity of flow [illegible]





$$V_{wi} = \frac{V_{fi}}{\tan 25} = \frac{V_{fi}}{.467} = 2.145 V_{fi}$$

$$u_i = \frac{V_{fi}}{\tan\beta} + \frac{V_{fi}}{\tan 25}$$

$$= .268 V_{fi} + 2.145 V_{fi}$$

$$= 2.413 V_{fi}$$

$$V_o = V_{fi} = V_{fo}$$

$$\frac{V_{wi}u_i}{g} = H - \frac{v_o^2}{2g}$$

$$\frac{2.145\,V_{fi} \cdot 2.417\,V_{fi}}{32} = 15 - \frac{V_{fi}^2}{2\times 32}$$

$$\frac{5.17\,V_{fi}^2}{32} + \frac{.5V_{fi}^2}{32} = 15$$

$$\frac{5.67\,V_{fi}^2}{32} = 15 \qquad V_{fi} = \sqrt{\frac{15\times 32}{5.67}} = \sqrt{\frac{480}{5.67}} = \sqrt{84.7} = 9.2\ \text{ft}/_{sec}$$

$V_{fi} = V_{fo} = v_o = 9.2\ \text{ft}/_{sec}$ $\qquad v_r = \frac{9.2}{\sin 25} = 19.72$

$$w_D = \frac{V_{wi}u_i}{g} = \frac{(9.2)^2\times 5.17}{32} = \frac{84.7\times 5.17}{32} = 13.7\ \text{ft-lb}/_{lb}$$

$$\text{effy} = \frac{2g\,w_D}{u_i^2} = \frac{2\times 32\times 13.7}{19.72^2} = 87$$

$$\text{Hyd. effy} = \frac{H - v_o^2/2g}{H}\times 100 = \frac{15 - \frac{9.2^2}{64}\times 100}{15} = \frac{15 - 1.323}{15} = \frac{13.677}{15}\times 100 = 91.3\%$$

(6) [illegible] Reaction turbine [illegible] total head [illegible] 90' [illegible] turbine [illegible] tangential velocity 50 ft ps [illegible] turbine [illegible] out let pipe [illegible] 1' [illegible] turbine [illegible] 50 gallons/$_{sec}$ [illegible] radial velocity of flow [illegible] (a) curved vane [illegible] (b) guide blade angle [illegible] (c) turbine H.P [illegible]
(vel: of flow constant)

Radial flow

$$V_{fo} = v_o = \frac{\text{discharge}}{\text{pipe Area}} = \frac{50.0}{62.4\times\frac{\pi}{4}(1)^2} = \frac{500}{62.4\times.7854} = \frac{500}{49.2}$$

$V_{fo} = v_o = 10.15\ \text{ft}/_{sec}$

vel: of flow const $\therefore$ $V_{fo} = V_{fi} = 10.15$

$u_i = 60\ \text{ft}/_{sec}$

$$\frac{V_{wi}u_i}{g} = H - \frac{v_o^2}{2g}$$

$$\frac{V_{wi}\times 60}{32} = 90 - \frac{10.15^2}{64} \qquad V_{wi} = \frac{90 - 1.61}{1.562} = \frac{88.39}{1.562}$$

$$V_{wi}\times 1.562 = 90 - \frac{103}{64} \qquad = 56.5\ \text{ft}/_{sec}$$

$\alpha = \tan^{-1}\frac{10.15}{56.5} = \tan^{-1}.1795 = 10.2°$

$\theta = \tan^{-1}\frac{10.15}{5.5}$

$= 59.2$

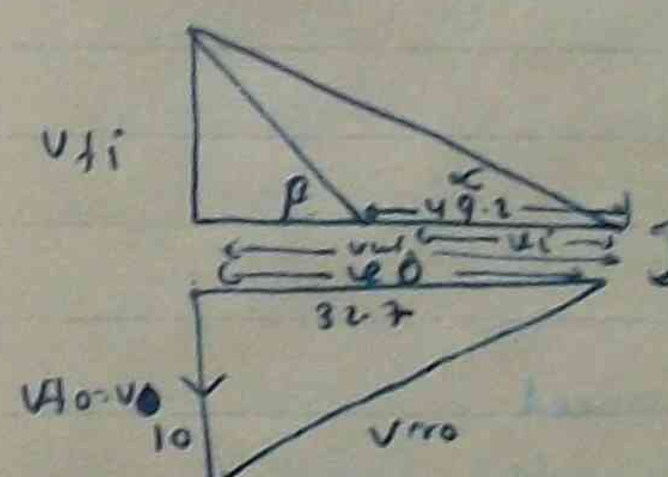
$\frac{V_{wi}u_i}{g} = w_D = 88.39\ \text{ft-lb}/_{lb}$

[illegible] HP $= \frac{88.39}{550}$ HP

62 500 lb ——— ? $= \frac{88.39\times 500}{550} = 80.2$ H.P

***

(7) [illegible] Reaction turbine [illegible] total head 50' [illegible] Turbine [illegible] 375 r.p.m. [illegible] 100 HP [illegible] 30" [illegible] 20" [illegible] Blade [illegible] 10 ft/$_{sec}$ [illegible] discharge [illegible] radial [illegible] Turbine [illegible] actual effy [illegible] theoritical effy [illegible] actual effy 84% [illegible] Guide blade angle [illegible] moving blade angle [illegible] Turbine breadth [illegible]



$\omega = \frac{2\pi N}{60} = \frac{2\times 3.14\times 375}{60} = \frac{628\times 375}{60}$

$\omega = \frac{2356}{60} = 39.3$

$u_i = \omega r_o = 39.3\times\frac{30}{12\times 2} = 39.3\times 1.25$

$= 49.2\ \text{ft}/_{sec}$

$u_o = \omega r_i = 39.3\times\frac{20}{12\times 2} = 39.3\times.833 = 32.7\ \text{ft}/_{sec}$

$$\frac{V_{wi}u_i}{g} = H - \frac{v_o^2}{2g} = 50 - \frac{100}{64.4} = 50 - 1.555$$

$= 48.445\ \text{ft-lb}/_{lb}$

$$\text{Theoritical effy} = \frac{H - v_o^2/2g}{H} = \frac{48.445}{50} = 96.8\%$$

$$HP = \text{act: effy}\times\frac{w_D/_{lb}}{550}\times \text{Total weight of water}$$

$$100 = \text{act: effy}\times\frac{88.445}{550}\times 21\times 62.4$$

$$\boxed{w_D/_{lb} = \underline{H}\ \text{actual effy}: [illegible]\ 2g}$$

$$\text{actual effy} = \frac{55000}{50.445\times 1312} = \frac{55000}{65500} = 84.0\%$$

$\frac{V_{wi}u_i}{g} = 43.4$

$V_{wi} = 31.6\ \text{ft}/_{sec}$

actual effy 84% [illegible]

$100 = .84\times\frac{w_D/_{lb}}{550}\times 8\times 44\times 62.4$

$100 = .84\times\frac{V_{wi}u_i}{g\times 550}\times 21\times 62.4$

$V_{wi}u_i = \frac{100\times 32.2\times 550}{.84\times 21\times 62.4} = \frac{550.00\times 32.2}{62.4\times 17.63} = \frac{1772000}{1100} = 1612$

$V_{wi} = \frac{1612}{49.2} = 32.8\ \text{ft}/_{sec}$