Page 53 $c = f\lambda$ **PROBLEMS** (1) m.. c/s x m/s'

Ex(1) calculate the wave length of an electro magnetic radiation with frequency 5×10^{14} Hz

$c = f\lambda = 5\times10^{4} \times \lambda$

$300\times10^{6} = 5\times10^{4}\lambda \rightarrow \lambda = \frac{300\times10^{6}}{5\times10^{4}} = 60\times10^{2}$ m

Page 61

Ex 2 A Total flux of 3500 Lumens falls uniformly on an area of 15 m2. what is the illuminance on the surface of the area

$\cancel{\phi = \frac{E}{A}}$ $E = \frac{\phi}{A} = \frac{3500}{15} = 233.3$ Lux

Ex 3 The total Luminous flux of a 20W flourescent Lamp is directed uniformly on to a display board of 4 metres by 2 metres. what would be the illuminance of board surface if the flourescent Lamp has out put 40 Lumen/W

$E = \frac{\phi}{A} = \frac{40\times20}{4\times2} = 100$ Lux

Ex 4 A total of 672 Lumens is directed ~~to~~ perpendicular on a rectangular flat surface measuring 4m x 3m. what is the illuminance on the surface of the board

$E = \frac{\phi}{A} = \frac{672}{4\times3} = 56$ Lux

Ex5 What is the Luminous efficiency of a 36W flourescent Lamp with output of 3000 Lm.

~~40 lumen~~/w $\therefore$ $\cancel{\phi = 40 \times 36 = 1440}$

$$\eta_v = \frac{\phi}{P} = \frac{3000}{36} = 83.3 \, L/w$$

Ex6 A 40W Fluorescent Lamp has an output of 1800 Lumens. calculate the Luminous efficiency of Lamp.

$$\eta_v = \frac{\phi}{P} = \frac{1800}{40} = 45 \, L/w$$

$$\boxed{\eta_v = \frac{\phi_v}{P}}$$

η_v = Luminous efficiency Lumens/watt

ϕ_v = Luminous flux in Lumens

P = Lamp input power (w)

Ex7 The Luminous efficiency of an incandescent Lamp is 14 Lm/w, calculate the output Lumens from 60W Lamp.

$$\eta_v = \frac{\phi}{P} \longrightarrow \phi = \eta_v \times P = 14 \times 60$$

$$= 840 \text{ Lumens.}$$

$$\boxed{E = \frac{I}{d^2}}$$

Inverse square law
E = Illuminance (lux)
I = Luminous intensity candelas
d = distance from Light source.

8) calculate the illuminance on a surface that is 3m from 100 cd Light source.

$$E = \frac{I}{d^2} = \frac{100}{3^2} = \frac{100}{9} = 11.11 \text{ lux}$$

9) An illuminance of 200 Lx is present at a distance of 3m from a Light source. If the inverse square law is applicable what is the Luminous intensity of the source.

$$E = \frac{I}{d^2} \Rightarrow 200 = \frac{I}{3^2} \rightarrow I = 200 \times 9$$
$$= 1800 \text{ cd}$$

10) At what height should a Light source be mounted if its vertical luminous intensity is 5000 cd and it is required to provide a illuminance on working plane 100 Lx

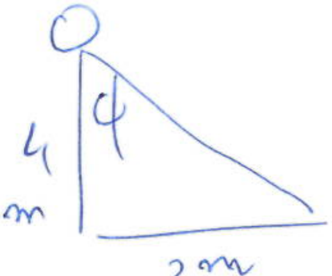
$$E = \frac{I}{d^2} \rightarrow 100 = \frac{5000}{d^2}$$

$$d = \sqrt{\frac{5000}{100}} = 7.07 \text{ m}$$

$$E = \frac{I}{d^2}\cos\theta$$

(11) A 2500 cd Light source is mounted 4 m above the floor, calculate the illumination
1. on the floor directly below the light
2. a point on the floor 3 m distant from directly beneath the light.

$$E = \frac{I}{d^2} \rightarrow \frac{2500}{4^2} = \cancel{277.77}\ 156.25 \text{ lux}$$



$$\tan\phi = 3/4 = 0.75$$

$$\phi = 36.86$$

$$E = \frac{I}{d^2}\cos\phi = \frac{2500}{4^2} \times \cos 36.86$$

$$= 125 \text{ lux}$$

P182

(1) A 2.5 mm² twin and earth flat TPS is installed unenclosed in air ~~and~~ for the connection of numerous socket outlets in a domestic home. Volt drop and temperature are negligible. Determine the recommendation number of single 10 A socket outlets that may be connected to this circuit if circuit protection is 16 A circuit breaker.

5

Table C9

cable size	CB = 16A	10A socket outlet
2.5mm^2	16A	2

cable size = 2.5mm^2, Installation type - Domestic

current carrying capacity — Table C6 — 25A (in air) AS/NZS 3000

Table C6

Loading (amp) each point contribute = 0.5A — AS/NZS Table C9

Total recommended number of points recommended ~~2 pt~~ 1 pt

Ex 2 — Refer Ex 1

Ex 3 — In the above pb, if installed in Aircon office

2 pt

Ex 4 — If Non Aircon office

2 pt

Ex 5 ⑥

A 20A socket outlet is wired with 2.5mm² twin earth flat TPS and installed an enclosed fully surrounded by thermal insulation. The socket is designated for a fixed appliance that draws 17 amp from supply and is protected by a 20A circuit breaker. Does this installati-on meet the requirement of AS 3000 wiring rules?

Table C6

2.5mm² / surrounded by thermal insulation

current 10 A is permissible

Now it draws 17 A

Table C9

2.5mm2 – 20 A CB – pt allowed 20 //

It does not comply with according to C6

Ex 7 You are to install a new power circuit using 4mm2 twin and earth flat TPS in a large warehouse. The circuit originates at DB in warehouse where it is installed enclosed in conduit for 30m before entering air conditioned office block where the remainder of the circuit is installed in air.

Determine the recommended number of 10A socket outlets that may be connected to circuit

(7)

Enclosed in air

4 mm² twin Table C6, current 25A

Table C7 - Protective device 25A

Table C8 - Am / % Vd = 20~~9~~ A (for 240V)

~~Table C9~~

30m × 25A = 750 A-m

$Vd = 2.5\% - \frac{750}{2.5} = 300$

Table C9 4 mm² → Aircon 10A socket

2

Ex (8) You are required to install 9 x double 10A single phase socket outlet in a factory store room (standard double power point) You install the cable partially surrounded in thermal insulation.

(a) Determine the required minimum CSA of flat twin and earth TPS to be used and circuit breaker

(b) Determine the required C.B to protect the circuit.

Table C 2   (2)   10A

9 - double socket outlet = 18 socket

Total power $1000 + 100 \times 17 = 2700W$

Current $= \dfrac{2700W}{240V} = 11.25$ Amp.

Table C6   Partially ~~surround~~ surrounded by thermal insulation

Twin TPS → 2 cores   cable size $1.5mm^2$

$16A \longrightarrow 1.5mm^2$

C.B   Table C7

$1.5mm^2$ (partially surrounded by thermal insulation)

C.B rating 13A

Ex (9) A $2.5mm^2$ 4 cores and each circular TPS is installed enclosed in air for the connection of a 3ϕ socket in a factory. volt - drop and temperature are negligible what is the maximum size C.B & socket outlet that may be installed.

Table C 7 (4 cores)   Enclosed in Air

$2.5mm^2 \longrightarrow 20A$

Ex10 A 20A 3ϕ socket outlet is installed in a factory. The circuit cable is $4mm^2$ and rated at 32A. The circuit is protected by a 20A C-B. The owner of the factory wants you to reinstall the ~~circuit breaker~~ circuit cable in conduit for added mechanical protection and replace 20A socket with a 32A socket. Is this permissible?

$\boxed{\text{Table C7}}$

		Air	CB
32A	$4mm^2$	(~~32A~~)	20A
	$4mm^2$	enclosed	If need, 25A CB

Table C9

20A single ph/multiph. socket

$4mm^2$ 25A (CB) —— 10 can be installed

But no recommendation for 32A socket

Not permissible.

P284 $\boxed{Ah = I \times t}$

Ex2 calculate the time required for discharge a 200Ah storage battery if a constant discharge current of 15A flows. Assume no losses.

$$Ah = I \times t \longrightarrow t = \frac{Ah}{I} = \frac{200}{15} = 13.3\,hr$$

Ex3 If the storage battery of Ex2 was discharged at a constant rate for 4 hr. how much current flowed? Assume no losses.

$$Ah = I \times t \rightarrow I = \frac{Ah}{t} = \frac{200}{4} = 50A$$

$$\boxed{\eta_{ah} = \frac{Ah_{out}}{Ah_{in}}}$$

Ex4 calculate the time required to charge 500Ah storage battery with a constant current of 70A. Assume the ampere-hour efficiency of the battery is to be 90%.

$$\eta_{ah} = \frac{Ah_{out}}{Ah_{in}} \times 100 \rightarrow 90 = \frac{I_{out} \times t}{500} \times 100$$

$$90 = \frac{70 \times t \times 100}{500} \Longrightarrow t = \frac{90 \times 500}{70 \times 100} = 6.4\,hr$$

$\boxed{Ah_{out} = I_{out} \times t}$

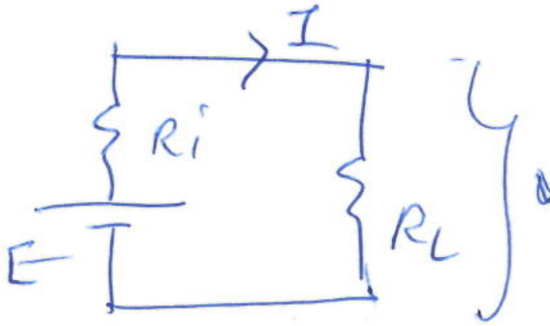
Ex5 A battery is rated at 150 Ah is to be charged at a constant current is 8 hrs. What will be the charging current if the ampere-hr efficiency is 90%.?

$$\eta_{h} = \frac{Ah}{Ain} \times 100 = \frac{I_{out} \times t}{Ain} \times 100$$

$$90 = \frac{I \times 8}{150} \times 100 \Rightarrow I = \frac{90 \times 150}{800} = 16.875\,A$$

$$\boxed{V_t = E - I R_i}$$

$$\boxed{I = \frac{E}{R_i + R_L}}$$



Ex6 A coil has a resistance of $0.5\,\Omega$ is connected to a cell with an open circuit voltage of 1.5 volt. Find the current flowing if the internal resistance of the cell is $0.1\,\Omega$.

$$I = \frac{E}{R_i + R_L} = \frac{1.5}{0.1 + 0.5} = \frac{1.5}{0.6} = 2.5\,A$$

Ex 7 A cell has an open circuit voltage of 1.5V. When a current of 880 mA flows in the cell, the terminal voltage drops to 1.15 V. Calculate the internal resistance of the cell.

$E = V_t + I R_i$

$1.5 = 1.15 + 0.88 \times R_i$

$R_i = \dfrac{1.5 - 1.15}{0.88}$

$= 0.397\ \Omega$

Ex 8 A cell has a terminal voltage of 1.3V and an internal resistance of 0.58 Ω. Calculate the open circuit voltage ~~of~~ if a current of 250mA flows in the cell.

$E = V_t + I R_i$

$E = 1.3 + 0.25 \times 0.58 = 1.445\,V$ ✓

Ex 11 Twelve 1.5V cells each with an internal resistance of 0.3 Ω are grouped in series to supply an external circuit having a resistance of 11.4 Ω. Determine the current supplied to the load.

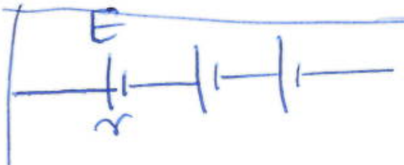
$E = 12 \times 1.5 = 18\,V$

$r_t = 12 \times 0.3 = 3.6\ \Omega$

$I = \dfrac{nE}{r_t + R}$

$= \dfrac{18}{3.6 + 11.4}$

$= 1.2A$

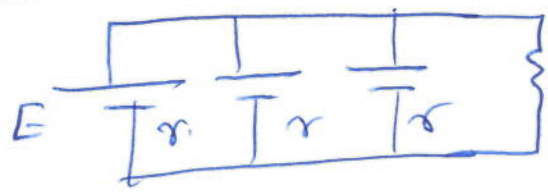


$nE = E_{total}$

$nr = r_{total}$

13

Ex 12 Twelve 1.5V cells each with internal resistance 0.3Ω are grouped in parallel to supply a load with a resistance of 0.275Ω. Determine the current delivered to the load.



$E_t = E$

$r_t = \frac{r}{n}$

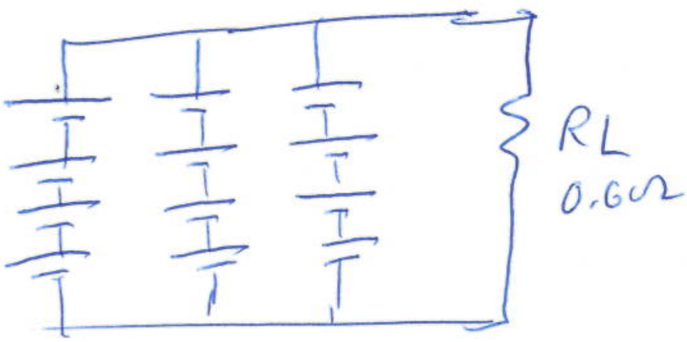
$E_t = 1.5V$

$r_t = \frac{0.3}{12} = 0.025\Omega$

$I = \frac{E_t}{r_t + R} = \frac{1.5}{0.025 + 0.275}$

$= 5A$

Ex 13 Determine terminal voltage and circuit current of battery consisting of 12 cells connected in series, parallel. Each cell has 1.5V, each group has 4 cells. Internal resistance 0.3Ω. Load resistance is 0.6Ω



$E = 4 \times 1.5 = 6V$

$E_t = 6V$

$r_{branch} = 4 \times 0.3 = 1.2\Omega$

$r_{total} = \frac{1.2}{3}\ 0.4\Omega$

$I\ \frac{E}{R + r_t} = \frac{6}{0.6 + 0.4} = \frac{6}{1} = 6A$

P307 11 calculate the continuous current that a battery with 300A-hr rating can deliver on 10 hr discharge

$$I = \frac{300}{10} = 30A$$

12 calculate the continuous current that the same battery in question 11 can deliver it it is discharged in 5 hours if the ampere-hr output is ~~10 80%~~ reduced to 80% of 10 hr rating.

$$300A\text{-hr} \longrightarrow 80\%\ \text{reduced} = \frac{80}{100} \times 300 = 240\ A\text{-hr}$$

$$I = \frac{Ah}{hr} = \frac{240}{5} = 48A$$

13 see the Example & do it yourself

14 A 12 V battery consisting of 6 cells requires 14.7 V to charge at 20 A. Find the internal resistance of each cell after charging has been completed.

$$E = V_t + Ir$$
$$14.7 = 12 + 20 \times r$$

$$r = \frac{14.7 - 12}{20} = 0.135\Omega$$

Ex15 Eight 1.5 volt cells are arranged in two parallel groups, if the cells are connected to a 12Ω load, Find the circuit if the internal resistance of each cell is 0.3Ω.

$nE = 1.5 \times 8 = 12\,V$

$nr_t = 8 \times 0.3 = 2.4\,\Omega$

$$I = \frac{nE}{nr_t + R_L} = \frac{12}{2.4 + 12}$$

$$= \frac{12}{14.4} = 0.833\,A$$

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$\boxed{W = P \times t}$

Ex1 A 1200W jug takes 3 minutes to boil water. how much energy is used?

$W = P \times t = 1200 \times (3 \times 60) = 216000\,J$

$= 216\,kJ$

Ex2 How long will it take a 1500W jug to boil water If 5000 Joules of energy is used.

$$t = \frac{W}{P} = \frac{5000}{1500} = 3.33\ \text{sec.}$$

$kWh = kW \times hr$

Ex3 A 240V radiator takes 2500W for 2hr. Calculate the amount of electrical energy used in kWh

$$kWh = \frac{2500 \times 2}{1000} = 5\,kWh$$

Ex4 A 240V range draws a current 32A for 60 minutes. Calculate the amount of electrical energy used in kWh.

$$kWh = kW \times hr = \frac{W}{1000} \times \frac{minute}{60} =$$

$$= \frac{V \times I}{1000} \times \frac{min}{60} = \frac{240 \times 32}{1000} \times \frac{60}{60}$$

$$= 7.68\,kWh$$

$$\boxed{\begin{aligned} W &= mc\,\Delta t \\ W &= mc\,(t_H - t_c) \end{aligned}}$$

Page 337 Ex5 Determine the heat required to heat 1 litre of water (1kg) from 20°C to boiling point 100°C

$$W = mc\,(t_H - t_c) = 1\,kg \times 1 \times (100 - 20)$$

$$= 80\,J$$

Ex6 A block of copper with a mass of 2 kg had 10 kJ of heat energy added. If the initial temperature of the block was 20°C, determine the final temperature of the block.

$$W = mc\,\Delta t = mc\,(t_H - t_c)$$

$$10\times10^3 = 2 \times 390\ (t_H - 20)$$

$$\frac{10\times10^3}{2\times390} + 20 = t_H \rightarrow 32.8°C$$

Ex7

Determine the heat required to heat 0.75 Litre of water in an aluminium saucepan with a mass of 0.25 kg from 20°C to boiling point 100°C. Assume heat losses to be zero

$$W = mc\ (t_H - t_c)$$

$$= 0.25\times 900(100-20)$$

$$= 0.25\times900\times80 = 18000\,J$$

$$= 18\,kJ$$

$$\boxed{\%\eta = \frac{W_{out}}{W_{in}}}$$

Ex 8 A 240V 6A jug raises temperature of 500 gm of water from 20°C to 70°C in 5 minutes. Calculate the efficiency of the jug

$W_{out} = mc\Delta t = mc(t_H - t_c)$

$= \frac{500}{1000} \times 1\,(70-20)$

$= 0.5 \times 50 = 25$ kJ

$W_{in} = V \times I \times t = 240 \times 6 \times 5 \times 60$

$= 432000$ J

$= 432$ kJ

$\%\eta = \frac{25}{432} \times 100 = 5.78\%$

Ex 9 A 250 gm 60W copper soldering raises temperature from 25°C to 125°C in 4.5 minutes. calculate efficiency of iron

$W_{out} = mc\Delta t = \frac{250}{1000} \times 390\,(125-25) = 9750$ J

$W_{in} = VIt = 60 \times 4.5 \times 60 = 16200$ J

$\%\eta = 9750/16200 \times 100 = 60\%$

Ex10 An electric jug has an efficiency 84%, and raises the temperature of 2000 mL of water from 15°C to 90°C in 6 min 40 sec. Calculate power input.

$$W_{out} = mc\Delta t = \frac{2000}{1000} \times 1 \times (90-15)$$
$$= 2 \times 75 = 150\ J$$

$$W_{in} = \frac{W_{out}}{\text{efficiency}} = \frac{150}{0.84} = 178\ J$$

$$W = P \times t \longrightarrow 178 = P \times (6 \times 60 + 40)$$
$$P = \frac{178}{400} = 0.446\ W$$

Ex11 consider a 2.5 mm² single conductor which has a resistance of 9Ω / km at 75°C. The current carrying capacity in air as NS/NZS 3000 is given in table C9 as 25A.

calculate produced energy

$$W = I^2 R t = 25^2 \times 9 \times 1\,sec = 5625\ J$$

Ex12 calculate for 20A

$$W = 20^2 \times 9 \times 1 = 3600\ J$$