STAGE (3) ADVANCED MECHANICAL ENGINEERING STUDY

GROUP (1) EXERCISES

ME 108 Principle of Engines

Assignment (82)

Q1161

Define (a) Caloric (b) Calories (c) Heat Energy (d) Applicability (e) Mole

Q1162

Define thermal conductivity

Q1163

Explain thermodynamic process in Adiabatic, Isothermal

Q1164

Write the following gas equations.

(a) Vanderwaal's equation
(b) Berthelot's equation
(c) Clausius' equation
(d) Dieterici's equation
(e) Redlich kwong's equation
(f) Virial equation

Q1165

(a) Explain the first law of thermodynamics
(b) Define entropy
(c) Define specific heat capacity

Q1166

Define the followings

(a) Heat capacity
(b) Molar heat capacity
(c) Write the equation for ideal non-atomic gas

Q1167

Define

(a) Enthalpy
(b) Change of state
(c) Latent heat

Q1168

(a) Define the efficiency of heat engine
(b) Sketch the characteristics curve for Carnot cycle.
(c) Sketch the characteristic curve for starling cycle.
(d) Write the efficiency equation for diesel cycle.
(e) What is heat pump?

Q1169

(a) Describe Nernst's heat theorem
(b) Describe Third law of thermodynamics

Q1170

Define valve

Q1171

What are geometric properties of valve?

Q1172

Describe intake flow.

Q1173

Describe exhaust flow.

Q1174

Sketch inlet and exhaust valve timing diagram.

Q1175

Write the formula to calculate the pipe length of intake valve and exhaust valve.

Q1176

Write the equation for the force acting on a car\

Q1177

Derive the equation for slider crank model.

Q1178

Write the equation to calculate mean effective pressure in engine.

Q1179

Write the equation for each process of basic Otto cycle.

Q1180

Sketch the graph for heat release model.

Q1181

What is Qin ?

Q1182

Write the equation to calculate heat transfer coefficient correlations.

Q1183

Write the solution model of mole of CO per moles of air.

Q1184

Write the chemical reaction regulation for air mixing with fuel in engine cylinder.

Q1185

What is chemical equilibrium?

Q1186

How much % of air/ fuel mixture energy is converted to work?

Q1187

(a) How do we determine engine heat transfer?
(b) What are typical heat transfer rates in engine?

Q1188

Sketch three resistor network of heat transfer in engine cylinder wall.

Q1189

Explain
(a) Conduction
(b) Convection
(c) Radiation of heat in car engine

Q1190

Describe cylinder heat transfer process.

Q1191

Write equation to calculate instantaneous heat transfer coefficient.

Q1192

Calculate
(a) Average heat transfer coefficient
(b) Average heat transfer per unit area of the cylinder to coolant
(c) Average heat transfer of the following engine
1000 rpm, 0.1 m stroke, combustion gas temperature 1000 °C , coolant temperature 80 °C

Q1193

Sketch the cooling system loop.

Q1194

Express the equation to calculate exhaust port heat transfer.

ME201 Introduction to fluid mechanic
Assignment (83)

Q1195

What are the properties of fluid?

Q1196

Define compressibility

Q1197

Explain the variation of pressure in static fluid.

Q1198

Write the equation to calculate buoyancy.

Q1199

Example

A pipe A with ID 100mm is connected to a pipe B with ID 65 mm through a converging cone (see figure Q41). Kerosene (ρ=800kg/m^3) is pumped through the pipe. If the average velocity in pipe A is 0.75 m/s, calculate

a) Velocity in pipe B
b) Mass flow rate in A
c) Mass flow rate in B

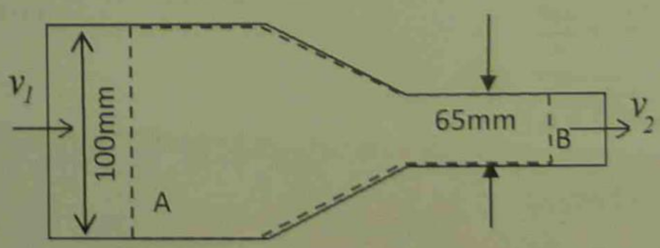


Figure Q4.1 control volume on a converging pipe section

Q1200

Describe

(a) Steady flow
(b) Unsteady flow
(c) Laminar flow
(d) Turbulent flow

Q1201

Consider a fluid with density 800 kgm^{-3}.

1. This fluid is placed in a 5 mm gap between two parallel plates. Top plate is moved with a constant velocity 0.25 ms^{-1} over the fixed bottom plate. It is found that the top plate experience a force 0.125 Nm^{-2}. Determine the kinematic viscosity of the fluid.
2. Same fluid is flowing in a pipe. The pipe diameter is 200 mm. A Pitot tube with an external manometer is connected to the pipe. The manometer fluid is water. The height difference between the water levels in the two legs is 33 mm.

a) Calculate the volumetric flowrate in the pipe.
b) Calculate the Reynolds number of the pipe flow.

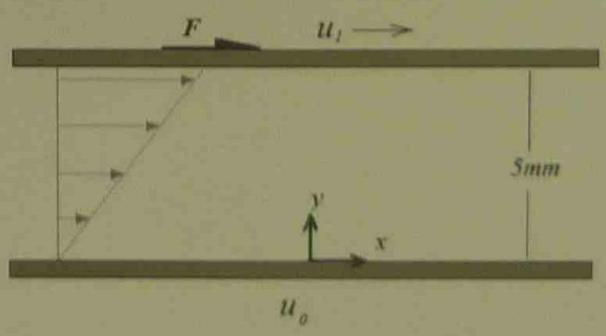


Figure Q4.21

Q1202

A water jet is used at a carwash is created by connecting a nozzle to a hose as shown in figure 3. The pressure at the entry section is 250kPa and the flowrate is 1liter/s. The entry section diameter is 25mm and the exit section diameter is 10mm. Determine the anchoring force required to hold the nozzle.

Answer

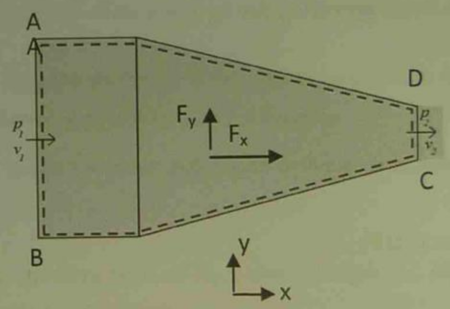


Figure Q4.4

Q1203

Write the equation to calculate all losses in water pipe.

Q1204

Dilute sulphuric acid is to be pumped between two storage tanks using 800 m long pipe with 5 cm inner diameter at a rate of 10 tonn/h. The overall vertical difference between the liquid levels of the two tanks is 15m. The tanks are open to atmosphere through vents. The specific gravity of the acid is 1.3 and the viscosity is 0.001 Pa s. In the pipework there is

a globe valve (fully open, equivalent to 100 pipe diameters) and four 90° standard radius bends (30 pipe diameters each). The relative roughness of the pipe is 0.002. Any other losses can be considered negligible. What power requirement of the centrifugal pump used if the efficiency of the pump is 63%?

Q1205

a) A centrifugal pump with an NPSH requirement of 5.8m is to be used to pump 160m^3/hr of saturated water at 120 °C. The minimum liquid level in the suction vessel is expected to be 7.5m above the pump inlet. The total equivalent length of the pipe (after compensating for the fittings) is 22m. The absolute roughness of the pipe is 0.046mm. Available pipe diameters are 200mm, 150mm, and 100mm. Select the appropriate pipe diameter that would make the satisfactory suction piping. Assume that the viscosity and the density of the water remain constant at 0.001Pa s and 1000kg m^{-3} respectively.

ME202 Introduction to Aero Dynamics
Assignment (84)

Q1206

Write the equation to lift and drag force acting on aeroplane

Q1207

For a cambered airfoil at an angle of attack of 5^0 the lift coefficient is 0.95 and pitching moment coefficient about quarter chord=-0.1. Find the location of the centre of pressure. What is the pitching moment coefficient about the leading edge of the airfoil?

Q1208

A cylinder with 5 cm diameter with a circulation Γ is placed in free stream with uniform velocity of 5 m/s. Calculate the value of Γ when both the stagnation points coincide on the body. Calculate the lift force acting on the cylinder. Assume density of air ρ=1.22 kg/m^{-3}.

Q1209

In a low speed wind tunnel, we have a settling chamber where the velocity of air is small and the cross section is large. The flow is taken from there through a converging passage where it accelerates before it reaches the test section where the model is kept for testing. If the cross sectional area, velocity and static pressure in the settling chamber and test section are A_S, V_S, p_S and A_T, V_T, p_T respectively find the velocity in the test section in terms of the other parameters.

Q1210

A normal shock wave is formed in air where upstream Mach number is 2 and upstream temperature, pressure and density are 300 K, 1 atm (i.e., 1 atmospheric pressure, which is approximately $1.01\times10^5\,N/m^2$) and $1.2kg/m^3$ respectively. Calculate Mach number, velocity, static temperature, static pressure, stagnation temperature and stagnation pressure downstream of the shock. Assume $\gamma = 1.4$.

Q1211

A supersonic flow at Mach number=2, temperature=300K, pressure=1atm and density=$1.2kg/m^3$ approaches a compression corner. An attached oblique shock with wave angle=45° is formed at the corner. Find the normal Mach numbers upstream and downstream of the shock. Also find M_2, p_2, p_{02}. Assume γ=1.4.

Q1212

The velocity profile for a laminar boundary layer developing on a flat plate is given by

$$u = a\sin(by) + c$$

Apply suitable boundary conditions and therefore evaluate the constants a,b and c

The boundary conditions for this problem are:

(a) At y=0, u=0 (no slip condition)
(b) At y=δ, u=U_ (free stream condition)
(c) At y=δ, $\frac{\partial u}{\partial y} = 0$ (zero shear condition)

Q1213

Explain the followings

(a) Open circuit wind tunnel
(b) Closed circuit wind tunnel
(c) Supersonic wind tunnel

ME204 Engineering Fluid Mechanics

Assignment (85)

Q1214

The temperature dependence of liquid viscosity is the phenomenon by which liquid viscosity tends to decrease as its temperature increases. Viscosity of water can be predicted with accuracy to within 2.5% from 0 °C to 370 °C by the following expression:

Q1215

A shaft 100 mm diameter (D) runs in a bearing 200 mm long (L). The two surfaces are separated by an oil film 2.5 mm thick (c). Take the oil viscosity (μ) as 0.25 kg/ms. if the shaft rotates at a speed of (N) revolutions per minute.

a) Show that the torque exerted on the bearing is given as:

$$Torque = \frac{\mu x \pi^2 x.NxL}{120xc} xD^3$$

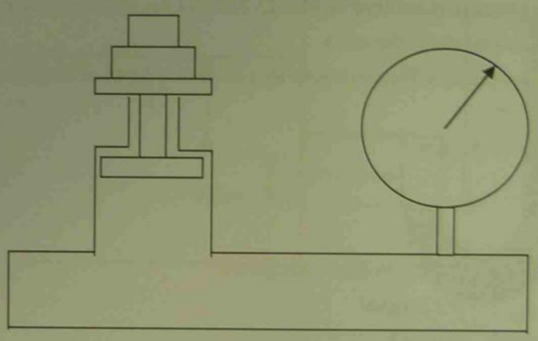
b) Calculate the torque necessary to rotate the shaft at 600 rpm.

Q1216

Explain Pascal's law.

Q1217

A dead-weight tester is a device commonly used for calibrating pressure gauges. Weights loaded onto the piston carrier generate a known pressure in the piston cylinder, which in turn is applied to the gauge. The tester shown below generates a pressure of 35 MPa when loaded with a 100 kg weight.



Determine:

a) The diameter of the piston cylinder (mm)

b) The load (kg) necessary to produce a pressure of 150kPa

Q1218

a) If the air pressure at sea level is 101.325 kPa and the density of air is 1.2 kg/m^3, calculate the thickness of the atmosphere (m) above the earth.

b) What gauge pressure is experienced by a diver at a depth of 10m in seawater of relative density 1.025?

Assume g = 9.81 m/s^2.

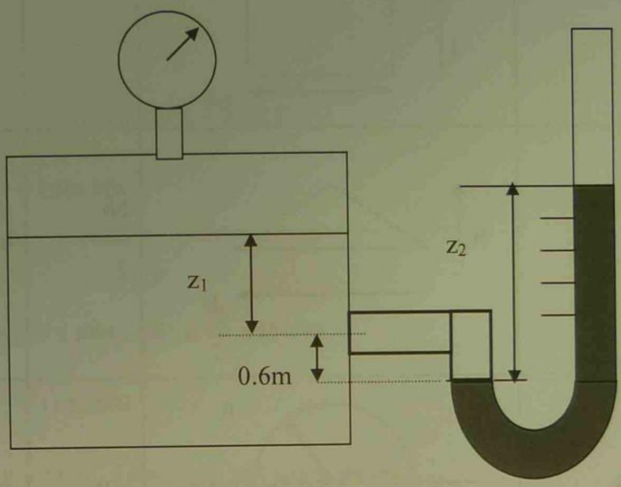
Q1219

Sketch the diagram of manometer.

Q1220

A U-tube manometer is connected to a closed tank, shown below, containing oil having a density of 860 kg/m^3, the pressure of the air above the oil being 3500 Pa. If the pressure at point A in the oil is 14000 Pa and the manometer fluid has a RD of 3, determine:

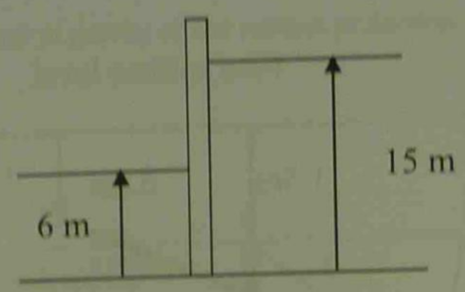
1. The depth of oil, z_1
2. The differential reading, z_2 on the manometer.



Q1221

A dock gate 10 m wide has sea depths of 6 m and 15 m on its two sides respectively. The relative density of seawater is 1.03.

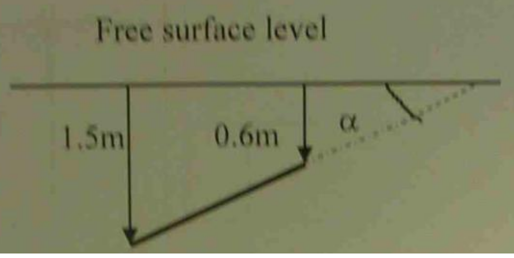
1. Calculate the resultant force acting on the gate due to the water pressure.
2. Find the position of the centre of pressure relative to the bottom of the gate.



Q1222

A flat circular plate, 1.25 m diameter is immersed in water such that its greatest and least depths are 1.50 m and 0.60 m respectively. Determine:-

1. The force exerted on one face by the water pressure,
2. The position of the centre of pressure.

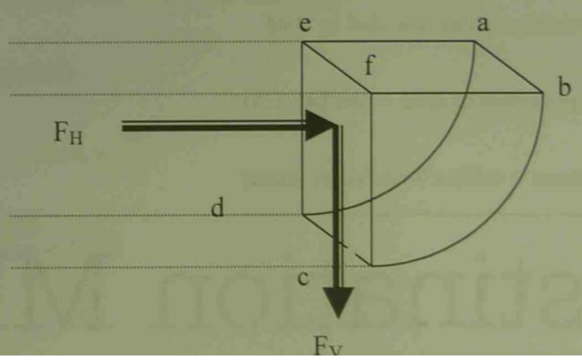


Q1223

The sluice gate shown below consists of a quadrant of a circle of radius 1.5 m. If the gate is 3m wide and has a mass of 6000 kg acting 0.6 m to the right of the pivot (e-f), calculate:-

1. Magnitude and direction of the force exerted on the gate by the water pressure,
2. The turning moment required to open the gate.

Solution:

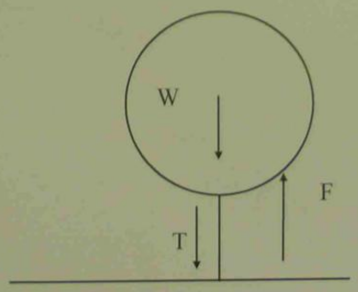


Q1224

A hydrogen filled balloon has a total weight force of 9.5 kN. If the tension in the mooring cable anchoring the balloon to the ground is 15.75 kN, determine the upthrust experienced by the balloon and its volume.

Take the density of air as 1.23 kg/m³.

Solution:

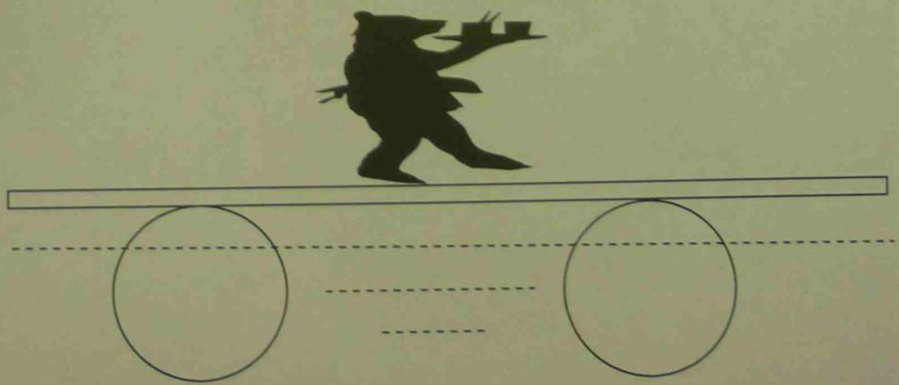


Q1225

A model boat consists of open topped rectangular metal can containing sand as a ballast. If the can has a width of 100 mm, a length of 500 mm, and a mass of 1 kg, determine the mass of sand (kg) required for the can to be immersed to a depth of 250 mm in sea water (RD = 1.03).

Q1226

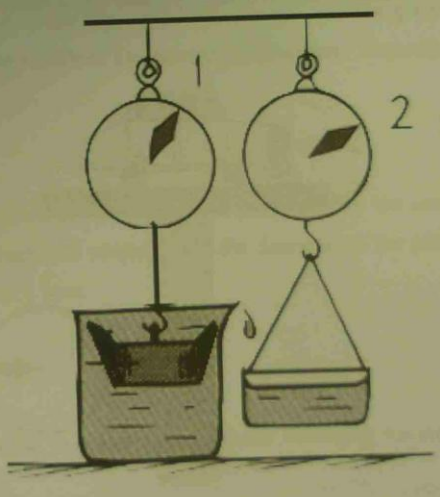
A raft floating in a river, supported by two drums, each 1m in diameter and 5m long.
If the raft is to stay afloat by 0.25m clear above water. What is the maximum weight that is allowed on it?
Assume density of water 1000 kg/m^3.



Q1227

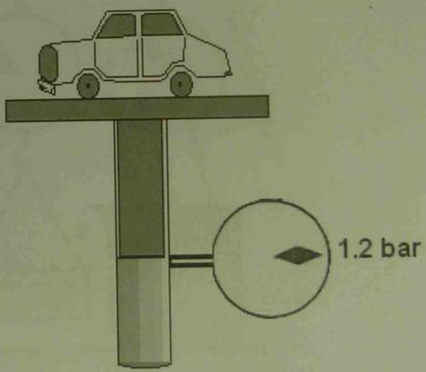
Worked Example 1.12

King Hero ordered a new crown to be made from pure gold (density = 19200 kg/m^3). When he received the crown he suspected that other metals may have been used in the construction. Archimedes discovered that the crown needed a force of 20.91 N to suspend when submersed in water and that it displaced 3.1×10^{-4} m^3 of water. He concluded that the crown could not be pure gold. Do you agree or disagree?



Q1228

The hydraulic jack shown, the piston weighs 1000 N, determine the weight of the car which is supported by the jack when the gauge reading is 1.2 bar. Assume that the jack cylinder has a diameter of 0.4 m.



Q1229

Air enters a compressor with a density of 1.2 kg/m^3 at a mean velocity of 4 m/s in the 6 cm x 6 cm square inlet duct. Air is discharged from the compressor with a mean velocity of 3 m/s in a 5 cm diameter circular pipe. Determine the mass flow rate and the density at outlet.

Q1230

A jet of water of 20 mm in diameter exits a nozzle directed vertically upwards at a velocity of 10 m/s. Assuming the jet retains a circular cross - section, determine the diameter (m) of the jet at a point 4.5 m above the nozzle exit. Take ρ_{water} = 1000 kg/m^3.

Solution:

Q1231

A Venturi meter fitted in a 15 cm pipeline has a throat diameter of 7.5 cm. The pipe carries water, and a U-tube manometer mounted across the Venturi has a reading of 95.2 mm of mercury. Determine:

1. the pressure drop in **Pascal's**, indicated by the manometer
2. the **ideal** throat velocity (m/s)
3. the **actual** flow rate (l/s) if the meter C_D is 0.975.

Q1232

Water flows in a 40mm diameter commercial steel pipe ($k = 0.045 \times 10^{-3}$ m) at a rate of 1 litre/s. Determine the frictio factor and head loss per metre length of pipe using:

1. The Moody diagram
2. Smooth pipe formulae. Compare the results.

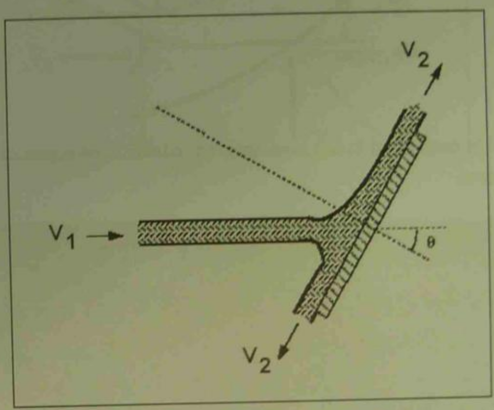
Take: $\rho = 1000$ kg/m³, $\mu = 1 \times 10^{-3}$ kg/ms

Q1233

Determine the input power to an electric motor ($\eta_m = 90\%$) supplying a pump ($\eta_p = 80\%$) delivering 50 l/s of water ($\rho = 1000$ kg/m³, $\mu = 0.001$ kg/ms) from tank1 to tank 2 as shown below if the pipeline length is 200m long, of 150 mm diameter galvanised steel (assumed surface roughness k=0.15mm).

Q1234

A jet of water having a diameter of 7.5 cm and a velocity of 30 m/s strikes a stationary a flat plate at angle $\theta = 30°$ as shown below.

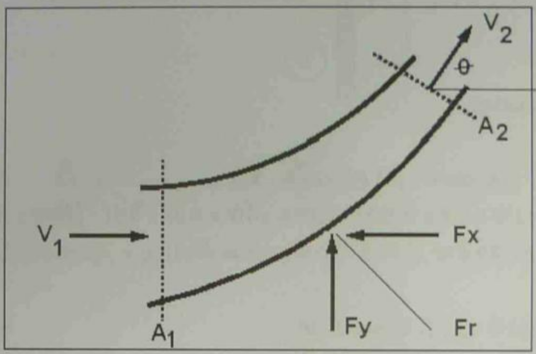


Determine the magnitude and direction of the resultant force on the plate assuming there is no friction between the jet and the plate. Take $\rho_{water} = 1000$ kg/m³.

Q1235

A bend in a horizontal pipeline reduces from 600 mm to 300 mm whilst being deflected through 60°. If the pressure at the larger section is 250 kPa, for a water flow rate of 800 l/s determine the magnitude and direction of the resulting force on the pipe.

Take $\rho_{water} = 1000\ kg/m^3$



Q1236

A siphon has a uniform circular bore of 75 mm diameter and consists of a bent pipe with its crest 1.4 m above water level and a discharge to the atmosphere at a level 2 m below water level. Find the velocity of flow, the discharge and the absolute pressure at crest level if the atmospheric pressure is 98.1 kN/m². Neglect losses due to friction.

Q1237

a) If the vertical component of the landing velocity of a parachute is 6 m/s, find the diameter of the open parachute (hollow hemisphere) if the total weight of parachute and the person is 950N.

Assume for air at ambient conditions, Density = 1.2 kg/m³ and Cd = 1.4

b) How fast would the man fall if the parachute doesn't open? Assume for that condition, Cd =0.5 and that the active area of the person's body is 0.5 m².

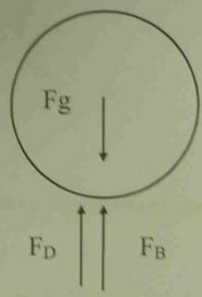
Q1238

Calculate the terminal velocity of sphere of density 6000 kg/m^3, diameter 0.1m falling through water of density 1000 kg/m^3, and its dynamic viscosity to be 0.001 kg/ms.

You may assume that the drag coefficient is given by $Cd = 0.4\ (Re/10000)^{0.1}$

Solution:

The Free body Diagram shows the three forces acting on the sphere



Since the system is stable, Newton's second law of motion applies:

Weight = Drag force + Upthrust (Buoyancy)

Q1239

An aeroplane weighing 100 kN has a wing area of 45 m^2 and a drag coefficient (based on wing area) $C_D=0.03+0.04\ xC_L^2$.

Determine:

1. the optimum flight speed
2. the minimum power required to propel the craft.

Assume for air at ambient conditions, Density = 1.2 kg/m^3

Q1240

A racing car shown below is fitted with an inverted aerofoil of length 1.2m and chord 0.85m at such angle that Cd=0.3 and Cl=1.3.

The car length is 4.6m, the body surface area is 11.5 m^2 and the skin friction coefficient is given by 0.0741 $Re_L^{-0.2}$ where Re is based on car length. The car weight is 12.75 kN and the rolling resistance is 40N per kN of normal force between the tyres and road surface. Assuming that the form drag on the car is 500 N when the car maintains a constant speed of 60 m/s, determine at this speed:

1. The total aerodynamic drag force on the car
2. The total rolling resistance, and
3. The power required to drive the car.

Q1241

Calculate the friction drag on one side of a smooth flat plate on the first 10 mm, and for the entire length when it is towed in water at a relative speed of 10 m/s. The flat plate is 10m long and 1m wide. Assume water density = 1000 kg/m^3 and its kinematic viscosity = 1.0x10^{-6} m^2/s. Use the Boundary layer equations to calculate the drag coefficient.

$$C_D = \frac{1.328}{\sqrt{Re_L}} \quad \text{laminar,} \quad Re_L < 5\times10^5$$

$$C_D = \frac{0.074}{[Re_L]^{\frac{1}{5}}} \quad \text{turbulent,} \quad 5\times10^5 \le Re_L < 10^7$$

Q1242

Air flows over a sharp edged flat plate, 1m long, and 1m wide at a velocity of 5 m /s. Determine the following:

1. the boundary layer thickness
2. the drag force
3. the drag force if the plate was mounted perpendicular to the flow direction. Take Cd =1.4.

For air, take density as 1.23 kg/m^3 and the kinematic viscosity for air as 1.46x10^{-5}m/s^2; Use the Boundary layer equations to calculate the drag coefficient.

Q1243

Water flows over a sharp flat plate 3 m long, 3 m wide with an approach velocity of 10 m/s. Estimate the error in the drag force if the flow over the entire plate is assumed turbulent. Assume the mixed regions can be expressed by the following coefficient of drag relationship

$$C_D = \frac{0.074}{(\text{Re})^{0.2}} - \frac{1742}{\text{Re}_L}$$

For water, take density as 1000 kg/m^3, and kinematic viscosity as 1.0x10^{-6} m/s^2.

Q1244

Calculate the speed of sound in air and in water at *0 °C and at 20 °C* and absolute pressure *1 bar*.

For air - γ = 1.4 and R = 287 (J/K kg)

For water K_s = 2.06 10^9 (N/m^2) and ρ = 998 (kg/m^3) at 0 °C, and 1000 (kg/m^3) at 20 °C

Q1245

An aircraft flies at an altitude of 10,000 m where the pressure and density are 0.265 bar and 0.41 kg/m^3 respectively.

a) Determine the aircraft speed if the Mach number is 1.5
b) What is the speed of the plane at sea level if the Mach number is maintained?

Q1246

A sealed tank filled with air which is maintained at 0.37 bar gauge and 18°C. The air discharges to the atmosphere (1.013 bar) through a small opening at the side of the tank.

a) Calculate the velocity of air leaving the tank; assume the flow to be compressible and the process to be frictionless adiabatic.
b) Compare the value if the flow is incompressible.
c) comment on the result.

Take for air, R=287 J/kgK, and γ= 1.4.

Q1247

A low flying missile develops a nose temperature of 2500K where the temperature and pressure of the atmosphere at that elevation are 0.03bar and 220K respectively. Determine the missile velocity and the stagnation pressure. Assume for air Cp=1000 J/kgK and γ=1.4.

Q1248

An air stream at 1 bar, 400 K moving at a speed of 400 m/s is suddenly brought to rest. Determine the final pressure, temperature and density if the process is adiabatic.

Assume for air: $\gamma = 1.4$. Cp = 1005 J/kgK and density = 1.2 kg/m^3.

Q1249

Describe

(a) Impulse turbine

(b) Reaction turbine

Q1250

Dinorwig power station has a head of 500m between the upper and the lower reservoir.

a) determine the approach velocity of water as it enters the turbine
b) if the volume flow rate is 60 m^3/s what is the diameter of the penstock
c) if the head loss due to friction represents 10% of the static head stated in (a), determine the actual velocity of approach and the corrected diameter of the penstock required.

Q1251

The average head of the water stored in the upper reservoir of the Dinorwig pumped storage system in Wales is 500 metre

a) Calculate the water flow rate through one of the turbo-generators when it is producing an output of 300 M at 94% efficiency.
b) The upper reservoir can store 7.2 million cubic metres of water. Show that this is enough to maintain the outp from all six 300 MW generators, running simultaneously, for a little over five hours.

Q1252

Calculate the specific speeds for Dinorwig power station described in the table below and recommend an appropriate type of turbine.

Power station	(P) Turbine rating (kW)	(h) Average head (m)	(N) Revolutions per minute	(Ns) Specific speed	Turbine type used
Dinorwig	300 000	500	500		

Solution

The last two columns are the solution to this question; the specific speeds are calculated using the definition of specific speed and the type of turbine/s were chosen according to table1.

Type Of Turbine	Specific speed range $Ns = N \frac{P^{1/2}}{(h)^{5/4}}$
Francis	70 – 500
Propeller	600 – 900
Kaplan	350 – 1000
Cross-flow	20 – 90
Turgo	20 – 80
Pelton, 1-jet	10 – 35
Pelton, 2-jet	10 – 45

$$Ns = N \frac{P^{1/2}}{(h)^{5/4}} = 500x300000\text{^}0.5/500\text{^}1.25 = 116$$

ME 206 Introduction to Turbo Machinery

Assignment (86)

Q1253

What is turbo machine?

Q1254

Sketch simple turbine operation and cascade view.

Q1255

Sketch 2D & 3d meridional view.

Q1256

Example Consider an Office Desk Fan. It rotates at 200 rpm and has a diameter of 30 cm. Air enters the fan at 3 m/s, parallel to the axis of rotation. Calculate the relative velocity ($\vec{W}$) at the tip of the fan.

Q1257

Explain aerofoil operation and testing.

Q1258

1. An aeroplane approaches a runway at 77 m/s with a crosswind of 15 m/s. What angle does the aeroplane have to face into the wind to travel directly towards the runway? *Answer:* 11°

revolution per second. The blade chord length is 0.5 m. Taking the design point at 85% maximum lift condition and ignoring the drag on the aerofoil estimate the power output per unit blade span at a radius of 6 m for each blade.

Q1259

Describe the design procedure of wind turbine.

Q1260

Example For a wind turbine with the same parameters as the previous example. That is: NACA 0012 aerofoil, air density of 1.22 kg/m^3, chord length of 0.5 m, rotational speed of one revolution per second. Calculate the wind speed at which the blade will stall at a 6m radius if the blade angle (γ) remains constant.

Q1261

Example If the blade hub section in the example above at a radius of 1.5m is designed to stall at the same wind condition, what would be the local blade angle?

Q1262

1. A two-blade wind turbine is designed to operate at an atmospheric condition (the air density can be taken as $1.22\ kg/m^3$) with a wind speed of $22\ mph$. The turbine blades of $10\ m$ length are attached to a nacelle of a radius of $1\ m$. A preliminary blading design is considered by using a NACA 0012 profile with a constant chord length of $1.5\ m$. The rotational speed of the turbine is $30\ rev/min$. The blading design is taken at a condition corresponding to 80% of the maximum lift.

   Calculate the blade angle and the power output per unit blade-span at 20%, 50% and 80% spanwise sections for each blade. Note that the blade starts at radius of $1\ m$ so the tip radius is $11\ m$. Estimate the total power output of the wind turbine using the results from the three spanwise sections and an approximate integration.

   Answers: $-53.8°$; $-72.4°$; $-80.8°$; $1.201\ kW/m$; $3.75\ kW/m$; $7.92\ kW/m$; $86 kW$

Q1263

Sketch radial pump

Q1264

Write the equation to calculate the water head of hydraulic turbine.

Q1265

Sketch 4 major turbines.

Q1266

Explain the common design choices of turbo machine.

Q1267

Example An industrial turbine operates at an 8.8:1 pressure ratio and a mass flow of $77\ kg/s$ using air as the working fluid. The exhaust temperature is at $43°\ C$ and the inlet temperature to the machine is around $1000°\ C$. The mean blade radius is $0.4\ m$. The machine is to be designed for a constant axial velocity of $200\ m/s$. Estimate the blade heights at entry and exit of the turbine.

Q1268

Example A turbine stage with a rotational speed of $3000\ rpm$ is to be designed with an absolute inlet angle of $60°$ and an absolute exit angle of $-60°$ at a mean radius of $0.4\ m$. The machine is to be designed for a constant axial velocity of $450\ m/s$. Estimate the specific work from this stage.

Q1269

Explain rothalpy in stator and rotor.

Q1270

Example A compressor stage working on air at 1 bar and 25°C has a work input of 17 kJ/kg and an isentropic efficiency of 0.9. The velocity at inlet and exit is the same. Assuming that the air properties are unchanged over the stage calculate the pressure output of the stage.

Q1271

Example A steam turbine stage operates with inlet conditions of $120 bar$ and 500°, the exit pressure is 10 bar. If the efficiency of the stage is 90% calculate the specific work output.

Q1272

Sketch basic h-s diagram

h-s diagram with ho

h-s diagram with ho and ho rel

Q1273

3

Example Given a turbine blade row with constant axial velocity of $150 m/s$ at $5000 rpm$ on a mean radius of 0.7 m and an absolute flow angle at exit from the stator of 70°. The turbine operates with axial leaving flow and is a repeating stage. Calculate the flow coefficient, stage loading coefficient and reaction.

Q1274

Example Given the power curve shown in Figure 7.2. Calculate the power output of the device at 10 rpm in a 10 m/s wind given that the turbine is 80m in diameter and the density of air can be taken as $1.15 kg/m^3$.

Q1275

Example A turbine is to be designed for a site with $400 m$ of head an an expected power of 1 MW, the turbine will feed electricity into a 50 Hz electrical grid. Using specific speed estimate which sort of turbine design should be investigated further.

Q1276

Example A turbine stage of a reaction 0.4 is to operate at a flow coefficient of 1.0, if the stator exit flow angle is 60°. Estimate the rotor relative inlet and exit flow angles.

Q1277

Example A steam turbine is to be supplied with superheated steam at conditions of 10 bar and 400°C the exhaust pressure is set to $4kN/m^2$. The turbine isentropic efficiency is expected to be around 88% based on past experience with machines of this type. The machine will rotate at 3000 rpm, a speed set by the electrical grid frequency. The mean radius of the machine will be 0.75 m.

Repeating stages, with constant axial velocity and axial leaving velocity are to be used. Estimate the number of stages and make a choice of blading with a stator exit angle of 75°.

Q1278

Example In the previous example the turbine is designed to produce 100 MW of power. At inlet the steam density is around 3.26 kg/m^3 (this can be checked with steam tables). Estimate the local blade height h.

Q1279

Explain

(a) Pelton wheel turbine

(b) Francis turbine

Q1280

Example Consider a machine with the following specification:

- Outer diameter of runner, $2r_2 = 2.0\,m$
- Rotational speed, $N = 200\,rev/min$
- Guide vane height, $b_2 = 0.3\,m$
- Vane blockage, $t = 0.08$
- Vane exit angle, $\alpha_2 = 75°$ from the radial direction
- Impeller designed for axial flow at exit, $\alpha_3 = 0$, and $r_{3m} = 0.5\,m$; $b_3 = 0.4\,m$
- Supply head, $H_O = 63\,m$; Flow rate $Q = 12\,m^3/s$
- Flow losses: $2\,m$ of heat loss in the supply pipe, $0.5\,m$ of head loss in the draft tube
- Draft tube velocity of $4\,m/s$

Determine the relative angles at inlet and exit of runner to give a preliminary design for the runner geometry. Also find the power output.

Q1281

Example Consider a Kaplan Turbine with the following characteristics:

- Guide Vane Exit: Radial flow, $r_2 = 2.0\,m$; blade height, $b_2 = 1.0\,m$, blockage, $t_2 = 0.08$; absolute flow angle to radial, $\alpha_2 = 50°$
- Runner: Mean radii at station 3 and 4 are the same: $r_{3m} = r_{4m} = 0.85\,m$, blade height, $b_3 = 0.7\,m$; designed for zero exit absolute swirl, $V_{4\theta} = 0$; rotational speed, $N = 300\,rev/min$.
- Draft Tube: Reduces axial velocity to $V_5 = 5\,m/s$
- Flow rate: $Q = 36\,m^3/s$

Calculate the runner relative and absolute flow angles and velocities at inlet and exit. Also calculate the power output.

Q1282

Example Using the Kaplan turbine in the previous example. Estimate the system efficiency if the draft tube loss coefficient is given by $k = 0.2$.

ME301 Fluid Dynamics

Assignment (87)

Q1283

Write the equation for temperature distribution in the pipe.

Q1284

Sketch diffusion of wave in pipe and express the equation.

Q1285

What are the forces in the fluid to be considered.

Q1286

Write continuity equation for compressible flow.

Q1287

Write the equations for incompressible flow.

Q1288

Explain turbulent flow.

Q1289

Write equation for inviscid flow.

Q1290

Describe finite element method.

Q1291

Explain the finite volume method.

Q1292

What is consistency

Q1293

What is stability

Q1294

Explain finite difference method.

Q1295

Explain finite element method.

Q1296

Explain finite volume method.