A PROBLEMS FOR PRACTICE

1 DENSITY

(Where necessary refer to the of values on page 4)

1.1 Calculate the density of a rectangular block 3 m by 2m by 1m if its mass is 24000 kg.

1.2 Calculate the density of the plastic foam used to make a sheet 2.0 m by 1.0 m by 100 mm if its mass is 4.0 kg.

1.3 A metal rod of density 7000 kg/m^3 and diameter 40.0 mm has a mass of 1.76 kg. Calculate its length.

1.4 A tangle of wire of density 8400 kg/m^3 and diameter 2.00 mm has a mass of 1.056 kg. Calculate the length of wire which has been tangled.

1.5 A porous metal cube of side 100 mm is made from metal of density 8000 kg/m^3 and has a mass of 7.2 kg. Calculate the volume of the pores in the metal if the mass of air they contain may be neglected.

1.6 A rectangular metal block of dimensions 200 mm by 100 mm by 100 mm has a hole in the middle. If the metal has a density of 6000 kg/m^3 and the block has a mass of 9.0 kg, calculate the volume of the hole. The mass of the air it contains may be ignored.

1.7 0.000300 m^3 of water is mixed with 0.000200 m^3 of a liquid of density 1500 kg/m^3. What is the density of the mixture, if there is no change in volume on mixing.

1.8 0.000 500 m^3 of a liquid of density 800 kg/m^3 are mixed with 0.000300 m^3 of a liquid of density 1200 kg/m^3. What is the density of the mixture. If there is no change in volume on mixing?

1.9 A liquid mixture of water and alcohol has a density of 850 kg/m^3. What is the proportion of each liquid (a) by volume, (b) by mass? (Assume that is no change in volume on mixing.)

1.10 An alloy has a density of 8000 kg/m^3. It is made from two metals of densities 10 000 kg/m^3 and 7200 kg/m^3. What is the proportion of each metal (by mass) in the alloy?

1.11 A bottle contained 200 g of a liquid of density 800 kg/m^3. The liquid is emptied out and 160 g of sand of density 3200 kg/m^3 is put in. What mass of water can now be poured in to fill the bottle?

1.12 A container holds 2.4 kg of brine. This is used up and is replaced by 4.0 kg of sand of density 3200 kg/m^3. The container is then filled up with water. What mass of water is needed?

2 MOMENTS: CENTRE OF GRAVITY

2.1 A metre rule is pivoted at its mid-point. If a 1.0 N weight is hung from the 20 cm mark. Where a 1.2 N weight must be hung to balance the first weight?

2.2 A uniform plank, 2.4 m long, is placed on a pivot at its mid-point. If John, of weight 500 N, stands on one end where must Paul, of weight 600N, stand to balance him?

2.3 A metre rule is pivoted at its at its mid-point. If a 2.0 N weight is hung from the 10 cm mark and a 3.0 N weight from the 30 cm mark, where must a 5.0 N weight be hung to balance the system?

2.4 A uniform plank, 3.0 m long, is placed on a pivot at its mid-point. If Jill, of weight 400 N, stands on one end and Jane, of weight 200 N, stands on the same side but 1.0 m from the end, where must June, of weight 500 N stand to balance them?

2.5 A metre rule is pivoted at its mid-point. A 3.0 weight is hung from the 30 cm mark mark and a 10 N weight from the 80 cm mark. A spring balance is attached to the 90 cm mark and its position is adjusted until the rule is horizontal. What is the reading on the spring balance?

2.6 A thin metal rod, 2.00 m long, is pivoted at its mid-point. A sliding 5.0 N weight is placed on it 0.50 m from one end and a 10 N weight is placed 0.60 m from the other end. If one end of the balance and adjusted so that the rod is horizontal. What is the reading on the balance?

2.7 A uniform metre rule is pivoted at the 30 cm mark. It is balance when a mass of 200 g is hung from the 20 cm mark; what is the mass of the rule?

2.8 A uniform metre rule is pivoted at the 20 cm mark and is attached to a spring balance at the 100 cm mark. When the rule is horizontal the reading on the balance is 60 g. What is mass of the rule?

2.9 A uniform plank of length 3.00 and weight 200 N rests on two trestles each 0.40 m from an end. If a man, of weight are the reactions of the trestles on the plank?

2.10 A uniform floor board of length 2.00 m and weight 40 N lies across two joists each 0.50 m from an end. If Bill, of weight 560 N, stands on the board between the joists and 0.40 m from one of them, what are the forces exerted by the joists on the board?

2.11 A uniform plank, of length 3.00 m and weight 100 N, is placed over a ledge so that 1.00 m of the plank is not supported. John, whose weight is 400 N, is forced to walk along the plank. How far out can he go before the system collapses?

2.12 A diving board is fixed at one end by bolts which will just take a strain of 3000 N without snapping. The board is 3.0 m long and the last 1.8 m are not supported. What is the heaviest weight that can be placed at the free end without the bolts snapping? (Ignore the weight of the board itself.)

2.13 A balance is known to be faulty because it has unequal arms. When an unknown mass is placed in the left hand pan, masses to the value of 1.060 kg have to be placed in the right hand pan. With the object in the right hand pan the mass required is 1.142 kg. Calculate the true mass of the object.

2.14 A non-uniform rod is pivoted at its centre of gravity. When an unknown mass is hung from one end and a 10.0 kg mass with the unknown mass moved to the first end. What is the value of the unknown mass?

2.15 Two spheres of mass 3.0 kg and 2.0 kg are joined by a light rod so that their centres are 0.45 m apart. Where is the centre of gravity of the system?

2.16 A metal cube of side 80 mm is joined to one, made of the same metal, of side 20 mm so that one face of the small cube is joined to the centre part of one face of the large cube. Where is the centre of gravity of the system?

2.17 A disc of radius 28 mm has a hole of radius 7.0 mm cut from it so that the edge of the hole just touches the edge of the disc. Where is the centre of gravity of the remaining material?

2.18 A metal sphere of radius 40 mm has a spherical air hole of radius 15 mm in it and the centre of the hole is found to be where is the centre of the sphere. Where is the centre of gravity of the faulty sphere?

2.19 A non-uniform rod, lying in a horizontal position, can just be lifted at one end by a vertical force of 5.0 N and at the other by a vertical force of 4.0 N. If the rod is 1.8 m long, find the position of the centre of gravity and the weight of the rod.

2.20 A tapering rod, lying on a horizontal table, can just be raised at one end by a vertical force of 3.0 N and at the other by a vertical force of 2.0 N. If the rod is 1.0 m long, find the position of its centre of gravity and its weight.

3 MACHINES

3.1 A machine can raise a load of 200 N through a height of 6.0 m when an effort of 50 N is moved through 30 m. Calculate the efficiency of the machine.

3.2 A load of 300 N can just be raised when an effort of 60 N is applied to it through a suitable machine. If the load is raised 1.0 m when the effort moves 8.0 m, what is the efficiency of the machine?

3.3 Draw a simple pulley system with a velocity ratio of 4. If its efficiency is 75%, what effort is needed to raise a load of 450 N?

3.4 Draw a simple pulley system with a velocity ratio of 3. If its efficiency is 90%, what load can be raised by an effort of 100 N?

3.5 A screw jack has a pitch of 1.0 mm and is worked by an arm of length 70 mm. If its efficiency is 40%, what load can be raised by an effort of 10 N?

3.6 A screw press has a pitch of 5.0 mm and is worked by an arm of length 140 mm. If its efficiency is 25%, what force can be exerted by the press when an effort of 100 N is applied?

3.7 A barrel of weight 480 N is rolled up a plank 3.0 m long on to a lorry, so that it is raised through a vertical height of 1.0 m. If the efficiency of the process is 80%, what force was exerted (parallel to the plank)?

3.8 A safe of weight 900 N is slid down planks 4.0 m long from a lorry where it was 1.0 m above the ground. It is controlled by a rope during its descent. If the tension in the rope was 300 N, what was the efficiency of the process?

3.9 A 0.50 kW engine drives a machine which raises a load of 100 N through 2.0 m every second. What is the efficiency of the system?

3.10 What (output) power engine is needed to drive a machine which is 75% efficient and raises a load of 3600 N through 10.0 m each minute?

3.11 A machine of efficiency 60% raises a load of 200 N through a height of 12.0 m . What amount of energy is wasted in the process?

3.12 A machine raises a load of 300 N through a height of 210 m. If the efficiency is 70%, what amount of energy wasted in the process?

3.13 In a certain pulley system, of velocity ratio 5.0, the lower pulley block weighs 50 N. A load of 550 N can be raised by an effort of 150 N. What percentage of the effort is used in overcoming friction?

3.14 In a certain pulley system, an effort of 25 N working through a distance of 10 m raises a load of 60 N through a distance of 10 m of 2.5 m. The lower pulley block weighs 15 N. What percentage of the effort is used in overcoming friction?

4 PRESSURE

(Where necessary refer to the list of values on page 4)

4.1 A rectangular block of sides 3.0 m by 2.0 m by 0.10 m has a mass of 3000 kg. what is the greatest pressure it can exert when resting on a level, horizontal floor?

4.2 A car of weight 12000 N stands on level ground. The pressure in each of its (four) tyres is 300 000 N/m^2 (above atmospheric pressure). What is the area of contact between each tyre and the ground?

4.3 A water manometer shows a difference between the levels of 136 mm, when connected to a gas supply. What is the pressure of the gas and what would a mercury manometer connected to the same supply indicate? (Atmospheric pressure = 100 000 N/m^2)

4.4 A water and a paraffin manometer are connected to the same gas supply. If the water manometer shows a difference between the levels of 160 mm, what will be the corresponding reading for the paraffin manometer, and what is the pressure of the gas supply? (Atmospheric pressure = 100 000 N/m^2).

4.5 A U-tube contains oil and water. The vertical height of the water-air surface is 200 mm from a horizontal bench, that of the oil-air surface 220 mm and that of the oil-water surface 120 mm. What is the density of the oil?

4.6 A U-tube contains paraffin and water. The vertical height of the water-air surface is 272 mm from a horizontal bench, and that of the paraffin-air surface 312 mm. Assuming the densities of the liquids, calculate the height of the water-paraffin surface from bench.

4.7 A mercury barometer reads 756 mm at ground level and 696 mm at the top of a mountain. If the average density of the air is 1.20 kg/m^3, calculate the height of the mountain.

4.8 A mercury barometer reads 762 mm at ground level. What would it read at the top of a mountain 2720 m high, if the average density of the air is 1.20 kg/m^3 ?

5 ARCHIMEDES' PRINCIPLE: THE PRINCIPLE OF FLOTATION

(Where necessary refer o the list of values on page 4)

5.1 A solid block has a volume of 0.002 0 m^3 and a weight in air of 80 N. what is its apparent weight when half immersed in a liquid of density 1 200 kg/m^3?

5.2 A cube of metal of side 0.10 m has a weight in air of 70 N. What will it weigh when three-quarters immersed in a liquid of density 800 kg/m^3?

5.3 A beaker of water is placed on a lever balance which indicates a weight of 50 N. A solid of weight (in air) 60 N and volume 0.002 0m3 hangs from a spring balance. What do both balances read when the solid is totally immersed in the water, but without touching the beaker ?

5.4 A metal cube of side 0.050 m and weight in air 8.0 N hangs from a spring balance. A beaker of paraffin is placed on a compression balance which reads 6.0 N. What is the reading on each balance when the cube is lowered into the paraffin and totally immersed but without touching the beaker ?

5.5 A solid weighs 147 N in air and 98 N when totally immersed in water, what is its density ?

5.6 A block of metal weight 245 N in air and 196 N when totally immersed in water. What is its density ?

5.7 A solid weighs 980 N in air, 784 N when totally immersed in water and 588 N when totally immersed in another liquid. What is the density of the solid and of the liquid ?

5.8 A block of metal weighs 1 960 N in air, 1470 N when totally immersed in water and 1 274 N when totally immersed in another liquid. What is the density of the solid and of the liquid ?

5.9 A metal cube weighs 196 N in air and 98 N when three-quarters immersed in water or half immersed in another liquid. What is the density of the metal and of the liquid ?

5.10 A plastic block weighs 294 N in air and 49 n when half immersed in water or three-fifths immersed in another liquid. What is the density of the plastic and of the liquid ?

5.11 A solid weighs 392 N in air and 294 N totally immersed in water. What does it weigh when half immersed in a liquid of density 1 200 kg/m^3 ?

5.12 A cube of metal weighs 588 N in air and 490 N when totally immersed in water. What does it weigh when half immersed in a liquid of density 800 kg/m^3 ?

5.13 A piece of metal is hung from one end of a uniform metre rule, pivoted at its mid point. It is balanced by a 50 N weight hanging from the 75 cm mark on the rule. If the volume of the metal is 0.001 0 m^3 to what point must the balancing weight be moved to keep the rule horizontal, if the metal is totally immersed in water ?

5.14 A piece of metal is hung from the 25 cm mark on uniform metre rule pivoted at its centre. A 10N weight hangs from the 100 cm mark. The metal is totally immersed in water. To where must the point of suspension of the metal be moved in order to balance the system, if the volume of the metal is 0.00050 m^3?

5.15 A piece of wood floats three-quarters immersed in water. What is its density?

5.16 A piece of plastic floats with three-fifths of its volume immersed in water. What is its density ?

5.17 A hydrometer has a bulb of volume 0.000022 m^3 and a stem of cross-sectional area 0.000 10 m^2. If its mass is 0.035 kg what length of the stem is immersed when it floats in water ?

5.18 A hydrometer floats with a 0.10 m length of its stem immersed in a liquid of density 1200 kg/m^3. If the volume of the bulb is 0.000 030 m^3 and the cross-sectional area of the stem is 0.000 15 m^2, what is the mass of the hydrometer ?

5.19 A raft has a volume of m^3 and is made of wood of density 550 kg/m^3. What load is it carrying if it is just totally immersed in sea water of density 1020 kg/m^3 ?

5.20 A platform of volume 2.0 m^3 is made of a material of average density 200 kg/m3. If it is floating in sea water of density 1020 kg/m3, how many men of mass 100 kg can it support without sinking?

5.21 A bottle has a volume of 0.0010 m^3 and a mass of 200 g. What extra mass must be placed inside the bottle if it is just to sink in a liquid of density 1 100 kg/m^3 ?

5.22 An oil drum has a volume of 0.045 m^3 and a mass of 30 kg. What mass of oil must be left in the drum if it is just to sink in sea water of oil must be left in the drum if it is just to sink in sea water of density 1 020 kg/m^3 ?

5.23 A bottle has a volume of 0.0030 m^3 and a mass of 1.0 kg. What mass of a metal of density 5 000 kg/m^3 must be attached to the outside of the bottle if they are just to sink in a liquid of density 800 kg/m^3 ?

5.24 A sealed rectangular tank of volume 3.0 m^3 and mass 700 kg is loaded externally with a metal of density 7000 kg/m^3 until it is just on the point of sinking in a liquid of density 1 200 kg/m^3. what mass of metal is needed ?

5.25 A balloon of volume 100m^3 and containing hydrogen of density 0.09 kg/m^3 floats in air of density 1.29 kg/m^3. If the mass of the envelope of the balloon is 50 kg, what is the tension in the tethering cable?

5.26 A balloon of volume 200 m^3 contains helium of density 0.18 kg/m^3. If it floats in air of density 1.28 kg/m^3 and the mass of the envelope and fittings of the balloon is 70 kg, what is the maximum load it can just lift?

6 VECTORS

6.1 Find the resultant of a force of 2.0 N acting due South plus a force of 5.0 N acting due East.

6.2 Find the resultant of a displacement of 5.0 m west plus a displacement of 4.0 m North.

6.3 A picture of weight 5.0 N is supported by two cords which make an angle of 30^0 to the vertical. What is the tension in each cord?

6.4 A loudspeaker system of weight 50 N is suspended from the ceiling of a hall by two chains, each making an angle of 40^0 to the vertical. What is the tension in each chain?

6.5 A man can row a boat at a speed of 2.0 m/s in still water. He has to row across a river which is flowing at a uniform speed of 0.5 m/s. In what direction must he steer to cross the river in the shortest time and what is this time if the river is 30 m wide?

6.6 An aircraft can fly in still air at a speed of 500 km/hr. The pilot is told to fly to an airfield 250 km due North. If there is a steady wind of velocity 25 km/hr due east in what direction must the pilot fly his aircraft and how long will the flight take?

6.7 A pendulum bob of weight 1.0 N is supported by a cord 1.0 m long. A horizontal force is applied to the bob and displaces it through a horizontal distance of 0.30 m. what was the value of the applied force?

6.8 A sphere of weight 10 N is supported by a cord 2.0 m long and is pulled to one side, through a horizontal force. What is the value of this applied force?

7 MOTION

7.1 A trolley pulls a tape through a ticker timer, which makes 100 dots a second. If the distance from the tenth to the twentieth dot is 170 mm and from the twentieth to the thirtieth dot is 270 mm, calculate the average acceleration of the trolley during this time.

7.2 A trolley pulling a tape through a ticker timer, which makes 100 dots a second, begins to move up a slope. If the distance from the fiftieth to the sixtieth dot is 340 mm, and from the sixtieth to the seventieth 220 mm, calculate the average decoration of the trolley during this period.

7.3 A car starting from rest accelerates steadily and acquires a velocity of 10 m/s in 12 s. It maintains this velocity for another 8 s and then brakes coming uniformly to rest in a further 10 s. Draw a velocity-time graph for the motion and calculate the distance travelled.

7.4 A lift accelerates upwards from rest at 1.0 m/s2 for 5 s, then travels at a steady speed for another 6 s and then comes steadily to rest in another 3 s. Draw a velocity-time graph for the journey and calculate the distance travelled.

7.5 A car is traveling at 10 m/s. it then accelerates steadily for 10 s and reaches a speed of 25 m/s. What was its acceleration?

7.6 A lorry is traveling at 8.0 m/s. It then accelerated uniformly at 0.5 m/s^2 for 20 s what is then accelerated uniformly at 0.5 m/s^2 for 20.s. What is its final speed.

7.7 A car is traveling at 15.0 m/s. It is then accelerated uniformly at 1.25 m/s2. What speed does it acquire when it has traveled a distance of a distance of 70 m from when the acceleration began?

7.8 A lorry is traveling at 10 m/s. It is then accelerated uniformly at a rate of 0.4 m/s^2. What speed does it acquire while traveling through the next 120 m?

7.9 A stone is throw upwards with a velocity of 14.7 m/s. How high does it rise?

7.10 A bullet is fired vertically with a velocity of 49 m/s. How high does rise/

7.11 A helicopter is rising at a steady speed of 8.0 m/s. A box dropped from the helicopter reaches the ground in 5.0 s. What was the height of the helicopter at the moment of release?

7.12 A bolt falls from a lift rising at a steady speed of 5.0 m/s. It hits the bottom of the shaft in 2.0 s. How far up the shaft was the lift when the bolt fell?

8 FORCE: MASS; ACCELERATION; FRICTION.

8.1A force of 2.0 N acts on a stationary mass of 5.0 kg. What is the acceleration produced and the velocity after 3.0 s ?

8.2 A stationary mass of 50 kg experiences a force of 30 N. what is the acceleration produced and velocity after 4.0 s ?

8.3 A mass of 3.0 kg rests on a smooth table and is tied by a light cord, passing over a frictionless pulley to a 5.0 kg mass hanging freely. What is the acceleration of the system when it is released ?

8.4 A block of mass 4.0 kg rests on a friction-less table and is connected by a light cord, passing over a frictionless pulley, to a freely hanging 6.0 kg mass. What is the acceleration of the system when it is released?

8.5 A mass of 2.0 kg and a mass of 3.0 kg are hanging freely from either end of a light cord which passes over a frictionless pulley. Calculate the acceleration of the system when released.

8.6 A mass of 4.00 kg and a stone are hanging freely from either end of a light cord which passes over a frictionless pulley. Calculate the mass of the stone if it accelerates downwards at 1.96 m/s^2 when the system is released.

8.7 A toy rocket has a mass of 100 g and experiences an initial thrust of 5 N. what is its initial acceleration ?

8.8 A rocket has a mass of 10 kg and on firing the thrust is 400 N. What is the initial acceleration?
8.9 A man of mass 100 kg stands in a lift which is accelerating upwards at 2.0 m/s^2. What force does the lift floor exert on him ?

8.10 A woman of mass 70 kg stands in a lift which is accelerating downwards at 3.0 m/s^2. What force does the lift floor exert on her ?

8.11 A block of weight 20 N is pulled at a steady speed across a rough surface, by a horizontal force of 16 N. What is the coefficient of friction between the block and the surface ?

8.12 A log of wood of weight 1000 N is being dragged along the ground at constant speed by a horizontal cable in which the tension is 200 N. What is the coefficient of friction between the wood and the ground?

8.13 A block of weight 40 N is placed on a horizontal table and connected by a light cord, passing over a frictionless pulley, to a 10 N weight hanging freely. What is the initial acceleration of the system (a) if the table is smooth, (b) if the coefficient of friction between the block and the table is 0.10 ?

8.14 A metal block of weight 20 N is lying on a horizontal table and it is connected by a light cord, passing over a frictionless pulley, to a weight of 30 N hanging freely. What is the initial acceleration of the system (a) if the table is smooth, (b) if the coefficient of friction between the block and the table is 0.10 ?

9 ENERGY; POWER

9.1 Calculate the gain in potential energy when a mass of 20 kg is raised through a height of 10 m.

9.2 John, of mass 80 kg, goes up a flight of stairs 6.0 m high. What is his gain in potential energy ?

9.3 A car of mass 900 kg is traveling at 30.0 m/s. What is its kinetic energy ?

9.4 A bullet of mass 10g is traveling at 30.0 m/s. What is its kinetic energy ?

9.5 A crane lifts a beam of mass 200 kg through a height of 30 m in 24.5 s. What power is needed/

9.6 A boy, of mass 60 kg, runs up a flight of stairs 5.0 m high in 3.0 s. What power does he exert?

9.7 A pump driven by an engine of output power 2.0 KW, raises 600 kg of water per minute through a height of 15 m. How much energy is wasted per minute in the pump ?

9.8 An engine of output power 1.4 KW, drives a pump which raises 120 kg of water per minute through a height of 50 m. How much energy is wasted per minute in the pump ?

9.9 What extra power must an escalator develop if it carries 20 people pf average mass 75 kg through a height of 8.0 m in one minute ?

9.10 How many people, of average mass 600 kg, can an escalator raise through a height of 10 m in one minute if the maximum power available is 4.9 kW?

9.11 A car, of mass 800 kg, is traveling at 25 m/s along a level road. How much extra power must the engine develop if the car is to climb a hill of 1 in 20 without a change in speed?

9.12 A car, of mass 720 kg, is traveling at 20 m/s along a level road. If it can develop a maximum a level road. If it can develop a maximum extra power of 4.9 kW, what is the greatest slope it can climb without a change in speed ?

9.13 A train, traveling at a steady 72 km/hr along a level track develops a power of 80 kW. What is the total resistance to motion which is being over come ?

9.14 The engine of a car which is traveling at a constant 90 km/hr along a level road develops a power of 7.5 kW. What id the total resistive force which is being over-come ?

9.15 A ball falls from a height of 20 m. If 10% of its energy is lost on impact, to what height does it rebound/

9.16 A rubber is thrown at a wall and hits it at a speed of 10 m/s. If 36% of its energy is lost on impact, at what speed does it leave the wall ?

10 MOMENTUM

10.1 A gun of mass 4.0 kg fires a bullet of mass 10 g a speed of 60 m/s. What is the initial speed of recoil of the gun ?

10.2 A large gun fires a shell of mass 5.0 kg with a muzzle velocity of 100 m/s. If the gun has a mass of 400 kg, what is its initial speed of recoil?

10.3 A man of mass 80 kg jumps off a trolley of mass 320 kg. If the initial speed of the man is 4.0 m/s, what is the initial speed of the trolley ?

10.4 A man of mass 70 kg, running at 5 m/s, jumps on to a stationary trolley, of mass 280 kg, and holds on to it. What is the initial speed of the trolley ?

10.5 A railway truck of mass 8000 kg, is traveling at 18 m/s along a horizontal track when it bumps into, and joins on to, two similar trucks which were at rest. What is the initial speed of the three trucks? How much energy is lost on impact ?

10.6 A loaded coal truck, of mass 10 000 kg, is traveling at 7.8 m/s along a horizontal railway track when it bumps into, and joins on to, three empty trucks of total mass 3000 k.g. What is the initial speed of the four trucks? How much energy is lost on impact ?

11 EXPANSION OF SOLIDS

(Where necessary refer to the list of values on page 4)

11.1 A rod of iron is 1.000 m long at 0^0C. what is its length at 100^0C ?

11.2 A brass rod is 0.800 m long at 200C. What is its length at 270^0C ?

11.3 A copper rod is 1.000 0 m long at 100C. At what temperature is its length 1.0085 m?

11.4 A steel rod is 2.000m long at 20^0C. At what temperature is its length 1.999 m ?

11.5 A steel cube of side 100.0 mm at 0^0C has a mass of 7.800 kg. What is the density of steel at 100^0C ?

11.6 A brass cube of side 50.00 mm at 0^0C has a mass of 1.050 kg. What would be the density of brass at 200^0C ?

11.7 A brass rod is 1.000 0 m long at 0^0C. A steel rod is 1.0 mm longer at the same temperature. At what temperature are they the same length ?

11.8 A copper rod is 2.000 0 m long at 20^0C. An iron rod is 0.5 mm longer at the same temperature. At what temperature are they the same length ?

11.9 A brass rod, 1.000 m long, and a copper rod have a constant difference in length at all temperatures. What is the length of the copper rod ?

11.10 A steel rod, 0.200 m long, and a brass rod, have a constant difference in length at all temperatures. What is the length of the brass rod ?

11.11 A hole in a steel plate has a diameter of 3.000 mm. What will be the diameter if the temperature of the plate rises 300 k ?

11.12 A hole in a steel plate has a diameter of 30,00 mm at 0^0C. At what temperature will a rod of diameter 30.03 mm just pass through the hole, assuming that the rod does not expand ?

12 THERMOMETRY

12.1 In a certain mercury thermometer the 0^0C mark is 63 mm from the bottom of the bulb and the 100^0C mark is 213 mm from the same point. When placed in a boiling liquid the mercury stops at a height of 108 mm. What is the temperature of the liquid ?

12.2 In a certain mercury thermometer the 0^0C mark is 187 mm, the 100^0C mark 27 mm and the top of the mercury 203 mm, all from the top of the tube. What temperature does the thermometer indicate?

12.3 A thermocouple connected to a galvanometer gives a zero reading when both junctions are in pure, melting ice and a reading of 3.5 mV when one junction is in steam at standard atmospheric pressure. If this junction is the placed in a boiling liquid the galvanometer reads 6.3 mV. What is the temperature of the boiling liquid ?

12.4 A thermocouple connected to a galvanometer gives a zero reading when both junctions are at 0^0C and a reading of 4.2 mV when one junction is heated to 100^0C. If it gives a reading of 6.3 mV in the opposite direction when this junction is placed in a melting solid, what is the temperature of this solid ?

13 SPECIFIC HEAT CAPACITY

[where necessary refer to the list of values on page 4]

13.1Calculate the final temperature if 6.0 kg of hot water at 70^0C are mixed with 4.0 kg of cold water at 100C.

13.2 Calculate the temperature which results if 7.0 kg of hot water 80^0 C are mixed with 3.0 kg of cold water at 20^0C.

13.3 calculate the final temperature if 10.0 kg of copper at 100^0 c are mixed with 7.6 kg of water at 30^0C.

13.4 What is the final temperature is 0.92 kg of boiling water (at 100^0C) is poured into an iron bucket, of mass 200 kg, at 20^0C ?

13.5 A lump of iron, of mass 3.0 kg and temperature 100^0 C is dropped into 4.6 kg of water at 20^0 c in an iron bucket of mass 2.0 kg. What is the final temperature ?

13.6 A copper sphere of mass 2.0 kg is heated to 200^0 C and dropped into 7.6 kg of water at 15^0 c in a copper container of mass 3.0 kg, What is the final temperature?
13.7 20 g of copper at 100^0C are dropped into 190 g of water at 20^0 C in a copper calorimeter of mass 100 g. What is the final temperature?

13.8 20 g of iron at 80^0 C are dropped into 230 g of water at 100C n an iron calorimeter of mass 50 g. What is the final temperature?

13.9 30 g of a metal at 90.00C are placed in 90 g of water at 20.0^0C in a calorimeter of mass 70 g. made of the same metal. If the final temperature is 22.1^0 c, calculate the specific heat capacity of the metal.

13.10 20 g of a metal at 100.0^0C are dropped into 80 g of water at 15.0^0C in a calorimeter. If the final temperature is 18.4^0C, calculate the specific heat capacity of the metal.

13.11 An iron nail of mass 4.0 g is heated in a Bunsen burner flame and dropped into 115 g of water, at 20.0^0 c, in an iron calorimeter of mass 90 g. If the final temperature is 22.0^0 C, calculate the approximate.

13.12 A brass 10 g mass is heated in an oil bath and then plunged into 190 g of water, in a copper calorimeter of mass 90 g, at 20.0^0C. If the final temperature is 21.5^0C, estimate the temperature of the oil bath.

13.13 What is the power of a heater which raises the temperature of 4.0 kg of methyl-lated spirits from 20^0C to 56^0C in 10 minutes?

13.14 What is the power of an immersion heater which can raise the temperature of 36 kg of water from 20^0C to 70^0 C in 1.0 hour?

13.15 A heater can raise the temperature of 2.4 kg of water from 20^0C to 70^0C in 10 minutes. If it is used to heat 2.1 kg of glycerine, how long does it take to raise the temperature from 15^0C to 40^0C?

13.16 A heater can raise the temperature of 1.1 kg of water from 200C to its normal boiling point in 21 minutes. How long would it take to raise the temperature of 3.0 kg of paraffin from 20^0 to 60^0C?

13.17 An electric kettle, made of copper, has a mass of 3.5 kg. It contains 3.0 kg of water and has an element rated at 2.8 kW. How long does it take to raise the temperature of the water from 20^0C to its normal boiling point?

13.18 An immersion heater in an iron tank of mass 40 kg, which contains 100 kg of water, can raise the temperature from 20^0C to 29^0C in one hour. What is the power of the heater?

13.19 Heater A can raise the temperature of a 4.0 kg block of aluminum from 21^0C to 32^0C in 9 mm 10 s, whereas heater B can raise the temperature of 10 kg of copper from 23^0C to 39^0C in 15 min 50 s. Which is the more powerful heater?

13.20 Two metal blocks, one made of iron and of mass 5.0 kg and the other of copper and of mass 6.0 kg, are placed in front of a fire. The temperature of placed of the iron rises from 20^0C to 47^0C in 11.5 min while that of the copper rises from 20^0C to 56^0C in 19 min. Which block is receiving the most heat per minute?

13.21 An 100W heater causes the temperature of a 4.0 kg block of metal to rise from 15^0C to 57^0C in 14 min. What is the specific heat capacity of the metal?

13.22 A 2 000W immersion heater can raise the temperature of 24 kg of a liquid from 17^0C to 42^0C in 10 min. What is the specific heat capacity of the liquid?

14 SPECIFIC LATENT HEAT

[where necessary refer to the list of values on page 4]

14.1 Calculate the heat energy required to convert 2.0 kg of ice at -20^0 C to (a) water at 0^0C (b) water at 30^0C. (c) steam at 100^0c.

14.2 Calculate the heat energy required to convert 3.0 kg of ice at -40^0C to **(a)** water at 0^0C, **(b)** water at 60^0C, **(c)** steam at 100^0C.

14.3 Calculate the final temperature if 2.1 kg of ice at 0^0C are mixed with 5.9 kg of water 40^0C.

14.4 Calculate the final temperature if o.63 kg of ice at 0^0C are mixed with 2.37 kg of water at 50^0C.
14.5 Calculate the final temperature if 1.05 kg of ice 0^0C are added to 1.62 kg of water at 70^0C, contained in a copper calorimeter of mass 4.20 kg.

14.6 Calculate the final temperature if 0.84 kg of ice at 0^0C are added to 2.0 kg of water at 50^0C , contained in an aluminum calorimeter of mass 0.63 kg.

14.7 0.21 kg of steam at 100^0C are condensed in 2.0 kg of water at 10^0C, contained in an iron calorimeter of mass 0.42 kg. What is the final temperature?
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14.8 0.084 kg of steam at 100^0C are condensed in 5.0 kg of water at 5.0^0C contained in a copper calorimeter of mass 0.63 kg. What is the temperature?

14.9 0.34 kg of steam at 100°C is condensed in a container of water at 34°C. What mass of ice at 0°C must be added and completely melted, if the final temperature of the water is also to be 34°C?

14.10 How much steam can be condensed in some water at 55 C without changing the temperature, if 4.5 kg of ice at 0°C are added and completely melted at the same time?

14.11 A lump of aluminum of mass 0.68 kg is cooled to a temperature of —120 C and then placed in a large quantity of water at 0°C. What mass of ice will form on the aluminum?

14.12 A piece of copper of mass 1.02 kg is cooled to a low temperature and then placed in a large quantity water at 0^0 C. 0.114 kg of ice forms on the copper. What was the temperature lo which the copper was cooled?

14.13 A refrigerator removes heal energy at the rate of 50W. How long will it take to turn 0.80 kg of water at 10°C into ice at 0°C? Ignore the thermal capacity of the container.

14.14 A refrigerator takes 42.4friin to turn 0.60 kg of water at 20°C into ice at 0°C. Calculate the rate at which the refrigerator is removing heat energy from (he water.

14.15 A hole is made in a large lump of ice at 0°C. A 1.7 kg mass of copper is dropped into the hole, another slab of ice is placed on top and eventually 0.38 kg of ice is f6und to have melted. Calculate the initial temperature of the copper.

14.16 A cavity is made in a large lump of ice at 0°C. A 0.17 kg mass of iron, healed to 300°C, is dropped into the cavity and another slab of ice is placed on top. How much ice will melt?

14.17 A 0.20 kg mass of a metal is just melted by heating it to 500°C. It is then poured into 2.0 kg of water at 20°C. If the final temperature of the water is 40°C and the specific heat capacity of the metal is 400 J/kg K, calculate its specific latent heat of fusion.

14.18 A 0.30 kg mass of metal at its melting point of 290°C, is dropped into 3.0 kg of water at 20°C, If the temperature of the water rises to 40°C and the specific latent heat of fusion of the metal is 440 000 J/kg, calculate its specific heat capacity.

14.19 An immersion heater rated at 3.4 kW is placed in a well stirred mixture of ice and water. How much ice is melted per minute?

14.20 A bunsen burner is placed under a beaker of ice and water. The mixture is well stirred and it is found that 12 g of ice melt per minute. What is the rate of supply of heat to the mixture?

14.21 An immersion heater takes 34 min just to melt a mass of ice at 0 C. How long does it take (a) just to boil the water formed, (b) to boil half of it away? Assume the heater works at a constant rate.

14.22 A heater, with a constant output, can just melt a mass of ice at 0°C, in 17 min. How long does it take (a) to raise the temperature of the water formed to 60°C, (b) to boil away one third of that water?

14.23 A refrigerator removes heat energy at *a* constant rate of 100W. An aluminum tray of mass 0.1 kg containing 0.2 kg of water at 20°C is placed in the refrigerator. How long does it take for the water to (a) reach 0°C, (b) turn to ice at 0°C?

14.24 A heater, which supplies heat energy at a constant rate of 200 W, is placed in a copper can of mass 0.2 kg containing 0.4 kg of ice. How long does it take (a) for all the ice to melt, (b) the temperature of the water formed to reach 30°C?

15 BOYLE'S LAW

[Where necessary refer to the list of values on page 4]

15.1 A certain mass of gas at *a* fixed temperature has a volume of 0.002 0 m^3 under a pressure of 100000 N/m^2. Calculate (a) its volume under a pressure of 400 000 N/m^3, (b) the pressure needed to give a volume of 0.004 0 m^3.

15.2 A certain mass of gas at a fixed temperature has *a* volume of 0.001 80 m^3 under a pressure of 80000 N/m^2. Calculate (a) its volume under a pressure of 120000 N/m^2, (b) the pressure needed to give a volume of 0.00360m^3.

15.3 A capillary tube, sealed at one end, contains an air space enclosed by a mercury thread 50 mm long. On a day when atmospheric pressure is 750 mmHg the length of the air space is 56 mm when the tube is horizontal. What is the length of the air column when the tube is turned to the vertical position, (a) with the open end uppermost, (b) with the sealed end uppermost? Assume no change in temperature.

15.4 A capillary tube, sealed at one end, contains an air space enclosed by a mercury thread 40 mm long. On a day when the atmospheric pressure is 760 mmHg; the length of the air space is 38 mm when the tube is vertical with the open end uppermost. What is the length if the tube is turned (a) to the horizontal position, (b) upside down?

15.5 A diver working at the bottom of a fresh water lake 20 m deep releases *a* stream of air bubbles, each of volume 0.000 003 m^3. What is the volume of each bubble just before it reaches the surface, if atmospheric pressure is 98000 N/m^2.

15.6 A faulty gas pipe lying at the bottom of a lake releases a stream of bubbles. If the volume of the bubbles increases to torn times the original volume in reaching the surface, calculate the depth of the pipe. (Atmospheric pressure = 102900 N/m ')

15.7 A diving bell is full of air at the surface of the sea. When it is lowered to the hoi him of the sea the water rises to fill one third of the bell. If atmospheric pressure is 98 000 N/m^2, estimate the depth of dm sea.

15.8 A tube of constant cross-section length 240 mm is sealed at one end and lowered, sealed end upwards into a fresh water lake. It is allowed to touch the bottom and is then brought up. It r. found that the lower 180 mm of the in side of the tube are wet. If atmospheric pressure is 98000 N/m^2, calculate HIM depth of the lake.

15.9 A gas cylinder contains 5.0 kg of gas at a pressure of 10 atmospheres. If the tap is opened what total mass of gas can escape?

15.10 A gas cylinder has a mass of 10 kg when evacuated and 20 kg when fully charged with gas at a pressure of 20 atmospheres. What would be its final mass if the Up were left open?

15.11 A glass tube in the shape of a letter J him the shorter limb sealed. Mercury is poured into the tube and adjusted so that the level in either limb is the same when the tube is vertical. The length of the air column in the sealed limb is 126 mm. Mercury is poured into the open limb until the length of the trapped air column becomes 84 mm. What is now the difference in level between the mercury in the limbs if a nearby mercury barometer reads 750 mm?

15.12 A glass tube in the shape of letter J has the shorter limb sealed and is clamped in a vertical position. Mercury is poured into it and the following measurements recorded: Height of end of sealed limb above bench 136 mm Height of mercury in sealed limb above bench 76mm. Height of mercury in open limb above bench 80 mm More mercury is added and the last two measurements become 91 mm and 345 mm respectively. Calculate a value for the reading on a nearby mercury barometer.

15.13 A mercury barometer is known to contain a little air. When the true barometer reading is 750 mm, the faulty barometer reads 740 mm and the distance from the top of the mercury to the end of the tube is 32 *mm*. What is the true reading when the faulty barometer reads 732 mm?

15.14 A mercury barometer is known to con-lain a little air. If the barometer reads 750 mm when the true pressure is 762 mm and on another day 744 mm instead of 754 mm, what is the distance from the zero on the scale to the top of the glass tube?

15.15 A vacuum pump has a volume of 0.001 0 m^3 and is connected to a vessel of volume 0.0090 m^3. The initial pressure in the vessel is 100000 N/m^2, What is the pressure after (a) 1 stroke, (b) 3 strokes of the pump?

15.16 A vacuum pump has a volume equal to one ninety-ninth of the volume of the en closure it is to evacuate. The initial pres- I sure is 100000 N/m^2. What is the pressure after (a) 1 stroke, (b) 2 strokes of the pump?

16 CHARLES LAW;

LAW OF PRESSURES;
IDEAL GAS EQUATION

16.1 A certain mass of gas has a volume of 0.12"m^3 at 27°C and a pressure of 120 000 N/m^2. Calculate *(a)* the pressure at constant volume and (b) the volume at constant pressure if the temperature rises to 127°C.

16.2 A certain mass of gas has a volume of 0.15 m^3 at -23°C and a pressure of 80000 N/m^2. The temperature is raised to 102°C at constant volume. What does the pressure become? Keeping this new pressure constant, the temperature is then raised to 227°C. What is the final volume?

16.3 Some gas is trapped by a piston in a cylinder at a temperature of 27 C. The temperature is raised to 327°C and the pressure is trebled. What happens to the volume of the gas?

16.4 A gas in an enclosed space has a volume of 0.012m^3 at a temperature of-23°C and a pressure of 60 000 N/m^2. What does the volume become at 22 7° C and 80 000 N/m^2?

16.5 A gas is collected and the volume recorded is 0.125 m^3 when the pressure is
570 mmHg and the temperature 102 C. What is the volume at s.t.p?

16.6 In a chemistry experiment a boy collects 202 $cm^3$of hydrogen at a temperature of 30°C and a pressure of 741 mmHg. What is the volume corrected to s.t.p?

16.7 The density of chlorine is 3.2 kg/m^3at s.t.p. What will it become at 91°C and 950 mmHg?

16.8 The density of helium is 0.18 kg/m^3 at s.t.p. What will it become at~91°C and 570 mmHg?

16.9 A glass bottle will withstand a pressure of 225 000 N/m^2. To what temperature may it be heated without shattering if it is sealed when it is at 27°C on a day when atmospheric pressure was 90 000 N/m^2?

16.10 A metal globe will withstand a pressure equal to 8 times that of the atmosphere. It was sealed at a temperature of "73 C. To what temperature may it be heated without exploding? (Ignore the expansion of the globe.)

16.11 A constant volume air thermometer gives an excess pressure reading of -12 mmHg with the bulb at 0°C, 138 mm at 100°C and 33 mm at an unknown temperature. What is the value of this temperature?

16.12 A constant volume air thermometer gives an excess pressure reading of 63 mm with the bulb at 0°C on a day when the atmospheric pressure is 756 mmHg. What would the express pressure reading be at 100°C?

17 RECTILINEAR PROPAGATION

17.1 A pinhole camera is made by drilling a small hole in the end of a box 150 mm long. If it is used to photograph a house 10 m high and 30 m away, how long will the image be on the film?

17.2 The distance from the pinhole to the film in a pinhole camera is 200 mm. It is used to take a photograph of a block of flats 40 m high and 100 m away. How high will the flats appear in the photograph?

17.3 A small light bulb is placed at one side of a room so that it is 1.0 m from a retort stand, 0.50 m high and 3.0 m from the ' wall in the same straight line. How tall is the shadow of the retort stand?

17.4 A small source of light throws a shadow of a coin held 100 mm from it. The dia-meter of the shadow is 0.25 m and the shadow is formed 2.0 m from the light. What is the diameter of the coin?

17.5 One type of electric light fitting gives a diffused, round source of light of effective diameter 0.20 m. A disc of diameter 0.10 m is held 0.50 m from the light. How far away must a screen be placed so that there is just no umbra in the shadow?

17.6 A largo electric light globe is 0.30 m in diameter. It casts a shadow of a disc of diameter 0.20 m. The disc is 1.0 m from the globe. How far away must a screen be placed to receive the shadow if the umbra is to be on the point of vanishing?

18 SPHERICAL MIRRORS

[These problems may be solved by drawing and/or calculation]

18.1 An object 10 mm high is placed 0.20 m in front of a mirror of local length 0.15 m. Find out as much as possible about the image if the mirror is.(a) convex, (b) concave.

18.2 An object 20 mm high is placed 0.60 m in front of a mirror of focal length 0.20 m. Find out as much as possible about the image if the mirror is (a) convex, (b) concave.

18.3 An object is placed in from of a concave mirror of focal length 0.18 m. The image formed has a magnification of three. Find the position of the object if the image is
(a) real, (b) virtual.

18.4 An object is placed in front of a concave mirror of focal length 0.16. The image formed has a magnification W four. Find the object position if the image is (a) real,
(b) virtual.

18.5 An object placed in front of a convex mirror of focal length 0.20 m produces an image 0.10 m from the mirror. Find the position of the object.

18.6 An object placed in front of a convex mirror of focal length 0.30 m produces an image 0.12 m from the mirror. Find the position of the object.

18.7 . An object placed 0.30 m in front of a concave mirror produces a real image 0.60 m from the mirror. Determine the focal length and radius of curvature of the mirror.

18.8 A concave mirror produces a real image of an object placed 0.20 m from it. If the distance from mirror to image is 1.50 m, determine the focal length and radius of curvature of the mirror.

18.9 A concave mirror has an object placed 0.10 m in front of it. If it produces an image with a magnification of four, find the focal length of the mirror if the image is real.

18.10 A concave mirror has an object placed 0.15 m in front of it. If it produces an image with a magnification of five, find the focal length of the mirror if the image ' is real.

18.11 A convex mirror produces an image which is diminished three times when an object is placed 0.60 m in front of it. Find the position of the image and the focal length of the mirror.

18.12 A convex mirror produces an image which is diminished four times when an object is placed 0.40 m in front of it. Find the position of the image and the focal length of the mirror.

19 REFRACTION

19.1 A ray of light, travelling in air, strikes a glass block of refractive index 1.50, at an angle of incidence of 20.0 . Calculate the angle of refraction.

19.2 A ray of light, travelling through a glass block of refractive index 1.50, reaches the surface with an angle of incidence of 29.0°. Calculate the angle at which it emerges into the air.

19.3 When light passes from air into a certain material the angles of incidence and refraction are 54.1° and 30.0° respectively. Calculate the refractive index of the material.

19.4 When light passes from air into a liquid the angles of incidence and refraction are 56.3° and 30.8° respectively. Calculate the refractive index of the liquid.

19.5 It is found that the critical angle for light going from glycerine into air is 42.9 What value does this give for the refractive index of glycerine?

19.6 It is found that the critical angle for light going from ice into air is 40.0 . What value does this give for the refractive index of ice?

19.7 A fish appears to be 0.90 m below the surface of water of refractive index 4/3 when viewed directly from above. What is the true depth of the fish?

19.8 A mark made on the bottom of a measuring cylinder appears to be 0.20 m below the surface of a liquid of refractive index 1.4 which fills the cylinder. What is the true depth of the mark?

19.9 What is the diameter of the smallest circular mat which, floating on the surface of some water, completely stops anyone above the water from seeing a mark which is 80 mm below the centre of the disc? Take the refractive index of water as 1.33.

19.10 A trough of liquid has a small torch bulb mounted so that the filament is 120 mm below the surface of the liquid. What is the diameter of the smallest circular mat which, floating on the surface of the liquid prevents any light escaping through that surface? The refractive index of the liquid is 1.40.

19.11 A ray of red light makes an angle of incidence of 60.0 with one face of a prism of refracting angle 60.0 . Calculate the angle at which the ray emerges from the second face of the prism if the appropriate refractive index of its material is 1.5.0.

19.12 A ray of blue light strikes a prism of *refracting* angle 50.0 at an angle of incidence of 40.0 . Calculate the angle at which the ray emerges from the second face of the prism if the appropriate refractive index of its material is 1.50.

19.13 A ray of green light enters a prism of refracting angle 60.0° and is just totally internally reflected at the second tune II the appropriate refractive index is 1.56, calculate the original angle of incidence of the light.

19.14 A ray of orange light enters a prism of refracting angle 70° and is just totally internally reflected at the second face. If the appropriate refractive index is 1.41, calculate the original angle of incidence of the light.

20 LENSES

[These problems may be solved by drawing and/or calculation except numbers 13 to 16 which are suitable for calculation only]

20.1 An object 20 mm high is placed 0.45 m from a lens of focal length 0.15 m. Find out as much as possible about the image if the lens is (a) converging, (b) diverging.

20.2 An object 30 mm high is placed 0.50 m from a lens of focal length 0:20 m. Find out as much as possible about (t the image if the lens is (a) converging, (b) diverging.

20.3 An object is placed in front of a converging lens of focal length 0.24 m. The image formed has a magnification of four. Find the position of the object if the image is (a) real, (b) virtual.

20.4 An object is placed in front of a: converging lens of focal length 0.15jm. The image formed has a magnification of three. Find the position of three. Find the position of the image is (a) real, (b) virtual.

20.5 An object placed in front of a diverging lens of focal length 0.16 m produces an image 0.12 m from the lens. Find the position of the object.

20.6 An object placed in front of a diverging lens of focal length 0.25 produces an image 0.15 m from the lens. Find the position of the object.

20.7 An object placed 0.25 m from a converging lens produces a real image 0.75 m from the lens. Find the focal length of the lens.

20.8 An object placed 0.30m from a converging lens produces a real image 0.90 m from the object. Find the focal length of the lens.

20.9 A converging lens has an object placed: 0.12 m in front of it. If it produces an image with a magnification of five, find the focal length of the lens if the image is real.

20.10 A converging lens has an object placed 0.16 m from it. If |it produces an image with a magnification of three, find the focal length of the lens if the image is real.

20.11 A diverging lens produces an image which is diminished three times, when an object is placed 0.18 m from it. Find the position of the image and the focal length of the lens.

20.12 A diverging lens produces an image which is diminished four times, when an object is placed 0.36 m from it. Find the position of the image and the focal length of the lens.

20.13 A camera is used to photograph an object which is 4.00 m from the lens. If the distance from the lens to the film is 129 mm, find the focal length of the lens.

20.14 A camera is used to photograph an object which is 15.0 m from the lens. If the focal length of the lens is 1 50 mm, find the distance from the lens to the film.

20.15 A projector is used in a room where the maximum distance from slide to screen is 8.40 m. If a magnification of 20 times is required, find the focal length of the projector lens which must be used.
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20.16 A film projector must give a magnification of 30 times, and the distance from
the lens to the screen is 7.5 m. Find the focal length of the lens which must be used in the projector.

20.17 A point source of light is placed 0.20 m from, and on the axis of, a converging lens of focal length 0.15 m and diameter 60 mm. A screen is placed 0.30 m behind the lens. Describe as fully as possible what is seen on the screen.

21 WAVES

21.1 Find the wavelength in air of a sound wave of frequency 1.1 kHz, if the velocity of sound in air is 330 m/s.

21.2 Find the wavelength in water of a sound wave of frequency 700 Hz, if the velocity of sound in water is 1.4 km/s.

21.3 The front of a plane wave travelling in one medium at a velocity of 200 m/s, meets a plane boundary with a second medium at an angle of 30°. If the velocity in the second medium is 150 m/s, find (by a scale drawing) the angle between the wave front and the boundary after refraction.

21.4 A plane wave, travelling at a speed of 250 m/s meets a plane boundary with a medium where the speed of the wave becomes 300 m/s. If the angle made by the wave front to the boundary, while the wave is in the first medium, is 20 find by a scale diagram, what it is when the wave is in the second medium.

21.5 Light, consisting of a mixture of green (wavelength 500 nm) and red (wave-length 700 nm), falls on to a diffraction grating which has 200 lines/mm.What is the angle between the two colours in the first order spectrum?

21.6 A mixture of blue (wavelength 450 nm) and yellow (wavelength 600 nm) light falls on to a diffraction grating which is 150 lines/mm. What is the angle between the two colours in the second order spectrum?

21.7 Violet light of wavelength nm falls on to a diffraction grating with 400 lines/mm. How many different orders can be observed?

21.8 Red light of wavelength 700 nm falls on to a diffraction grating with 500 lines/mm. How many diffracted orders can be observed?

22 RESISTANCE

22.1 What is the value of a resistor that passes a current of (a) 3.0 A, (b) 3.0 mA, (c) 3.0 μA, when a p.d. of 12 V is applied across it? the lens. Describe as fully as possible what is seen on the screen.

20.18 A point source of light is placed 0.12 m from, and on the axis of, a converging lens of focal length 0.080 m and diameter 90 mm. A screen is placed 0.16 m behind the lens. Describe as fully as possible what is seen on the screen.

21.5 Light, consisting of a mixture of green (wavelength 500 nm) and red (wavelength 700 nm), falls on to a diffraction grating which has 200 lines/mm. What is the angle between the two colours in the first order spectrum?

21.6 A mixture of blue (wavelength 450 nm) and yellow (wavelength 600 nm) light falls on to a diffraction grating which has 150 lines/mm. What is the angle between the two colours in the second order spectrum?

21.7 Violet light of wavelength 400 nm falls on to a diffraction grating with 400 lines/mm. How many diffracted orders can be observed?

21.8 Red light of wavelength 700 nm falls on to a diffraction grating with 500 lines/mm. How many diffracted orders can be observed?

22.2 What is the value of a resistor that passes a current of (a) 7.5 μ A, (b) 75 mA, (c) 0.75 A, when a p.d. of 15 V is applied across it?

22.3 What current flows through a 20 Ω resistor when a p.d. of (a) 40 V, (b) 4 mV, (c) 4 V is applied across it?

22.4 What curium (lows through a 1 000 Ω resistor when *a* p.d. of (a) 2 V, (b) 200 V, (c) 20 mV is applied across it?

22.5 What p.d. is needed to drive a cut rent of (a) 5.0 A, (b) 50 mA, (c) 0.50/.'A thmugh a 100n resistor?

22.6 What p.d. is needed to drive a current of (a) 0.28 A, (b) 280 μ A, (c) 280 M through a 2000 Ω resistor?

22.7 A length of fine wire has a resistance of 4.0 n/m. When a coil of it is connected to a 50 V supply a current of 20 mA flows. What is the length of wire in the coil?

22.8 A wire has a resistance of 7.5 n/m. When a reel of it is connected to a 15V supply a current of 0.10 A flows. What is the length of the wire on the reel?

23 RESISTORS IN SERIES AND PARALLEL

23.1 Calculate the effective value of a *6s2* and a 3s2 resistor when connected (a) in parallel, (b) in series.

23.2 Calculate the effective value of a 1 5s2 and a 10U resistor when connected (a) in parallel, (b) in series.

23.3 Calculate the effective value of a 6 **Ω**, a 3 **Ω** and a 2 **Ω** resistor when connected in paiallel.

23.4 Calculate the effective value of a 15 **Ω**, a 10 **Ω**, and a 6 **Ω** resistor when connected in parallel.

23.5 What is the total resistance of a 1 **Ω** resistor connected in series to a 25ii and a 50 **Ω** resistor which are in parallel?

23.6 What is the total resistance of a 7 **Ω** resistor connected in series to a 12 **Ω** and a 4 **Ω** resistor which ;m: in parallel?

23.7 A 10 **Ω** and a 17 **Ω** resistor are connected in parallel to a 6.8 V supply. What current flows through each resistor?

23.8 A 7.OH and a 20n resistor are connected in parallel to a 14 V supply. What current flows through each resistor?

23.9 A 16n and a 24 **Ω** resistor are joined in parallel and the two connected in series to a 5.on resistor. When the whole system is connected to a certain power supply a p.d. of 10 V is indicated by a voltmeter connected across the 5.0n resistor. What is the current in each resistor?

23.10 A 6.on and a 4.on resistor are joined in parallel and the two connected in series to an 8.OH resistor. When the whole system is connected to a certain power supply, a p.d. of 3.2 V is indicated by a voltmeter connected across the 8. **Ω** resistor. What is the current in each resistor?

23 11 What resistor must be connected in parallel with a 75n resistor to give a total effective resistance of 30S2?

23.12 What resistor must be connected in parallel with a 60n resistor to give a total effective resistance of 36 **Ω**?

23.13 A 12n, a 612 and a 4n resistor are connected in parallel. If the total current flowing through the group is 0.6A, calculate the current flowing through each resistor.

23.14 A 7552, a 50 **Ω** and a 30 **Ω**, resistor are connected in parallel. If the total current flowing through the group is 150 mA, calculate the current flowing through each resistor.

24 RESISTIVITY

24.1 A wire of length 1.0 m and cross-sectional area 2.0 mm^2 has a resistance of 0.40 **Ω**. What is the receptivity of the material of the wire?

24.2 A wire of length 20 m and cross-sectional area 0.50 mm^2 has a resistance of 8.0 **Ω** fl. What is the receptivity of the material of the wire?

24.3 A wire of length 15m has a resistance of 4.5 n. If the receptivity of the material of the wire is 0.60 μ **Ω** m, calculate the cross-sectional area of the wire.

24.4 A wire of length 8.0 m has a resistance of 16.0 n. If the receptivity of the material of the wire is 0.48 μ **Ω** m, calculate the cross-sectional area of the wire.

24.5 What length of wire of cross-sectional area 0.8 mm^2 and receptivity 0.40 μ **Ω** *m* is needed to wind a coil of resistance 5.0s2?

24.6 What length of wire of cross-sectional area 0.6 mm^2 and receptivity 0.72,uf2 m is needed to wind a coil of resistance 60 **Ω**?

24.7 The resistance of a certain wire is 8.0 *S2I*. What is the resistance of another wire of the same material but with three times the length and twice the radius of the first wire?

24.8 The resistance of a certain wire is 12 n. What! is the resistance of another wire of the same material but with half the length and half the radius of the first wire?

25 E.M.F. AND INTERNAL RESISTANCE

25.1 A cell of e.m.f. 2.0 V and internal resistance 0.50 **Ω** is connected to a 3.50**Ω** resistor. What current flows in the circuit and what is the p.d. across the resistor?

25.2 A battery of e.m.f. 6.0 V and internal resistance of 1. **Ω** is connected to a 11. **Ω** resistor. What current flows in the 25.4 circuit and what is the p.d. across the resistor?

25.3 A battery of e.m.f. 10.0 V and internal resistance 2.0n, a 3.0n and a 5.0 **Ω** resistor are connected in series. What current flows in the circuit and what is the reading on a voltmeter connected across the battery?

A battery of e.m.f. 12.0 V and internal resistance 0.50n, a 1.50X7 and a 4.00 **Ω** resistor are connected in series. What current flows in the circuit and what is the reading on a voltmeter connected across the battery?

25.5 A battery of e.m.f. 8.0 V and internal resistance 2.0 **Ω** is joined to a 15.0 **Ω** and a 10.0 **Ω** resistor which are connected in parallel. What current flows through each resistor?

25.6 A battery of e.m.f. 12.0 V and internal resistance 2.0 **Ω** is joined to a 6.0 **Ω** and a 3.0 **Ω** resistor which are connected in parallel. What current flows through each resistor?

25.7 Two 8.0 **Ω** resistors are connected in parallel and then the pair joined in series to a 2.0 **Ω** resistor and a battery of e.m.f. 14.0 V and internal resistance 1.0ft. What is the p.d. across the 2.0 **Ω**; resistor?

25.8 A 120 **Ω** and a 4.0 **Ω** resistor are connected in parallel and then the two are joined in series to a 8.0 **Ω** resistor and a battery of e.m.f. 24 V and internal resistance 1.0 **Ω**. What is the p.d. across the 8.0 **Ω** resistor?

25.9 A cell of e.m.f. 2.0 V and internal resistance 0.50 **Ω** is joined in series with a second cell of e.m.f. 1.0 V and internal resistance 2.50ft, and a 1.00 **Ω** resistor. What is the change in the current flowing in the circuit when *one* cell is reversed?

25.10 A battery of e.m.f. 12.0 V and internal resistance 2. **Ω** is joined in series with a second cell of e.m.f. 8.0 V and internal resistance 6.0 **Ω** and a 2.0 **Ω** resistor. What is the change in the current flowing in the circuit when *one* cell is reversed?
25.10

25.10 A battery of 10 accumulators, each of e.m.f. 2.0 V and internal resistance 0.10ft are to be charged from a 30 V supply. What resistor must be incorporated in the circuit to restrict the charging current to 2.0 A?
A battery of 20 accumulators, each of e.m.f. 2.2 V and internal resistance 0.05 **Ω** are to be charged from a 60 V supply. What resistor must be incorporated in the circuit to restrict the charging current to 1.6 A?

26 AMMETERS; VOLTMETERS

26.1 A milliammeter gives a full scale deflection for a current of 1.0 mA and has a resistance of 20 **Ω**. What resistor is needed to convert it into an ammeter reading to (a) 1.0 A, (b) 10 A, and how must the resistor be connected?

26.2 A milliammeter gives a full scale deflection for a current of 15 mA and has a resistance of 5.0 **Ω**. What resistor is needed to convert it into an ammeter reading to (a) 1.5 A, (b) 15 A, and how must the resistor be connected?

26.3 A milliammeter gives a full scale deflection for a current of 2.0 mA and has a resistance of 50 **Ω**. What resistor is needed to convert it into a voltmeter reading to (a) 5.0 V, (b| 250 V, and how must the resistor be connected?

26.4 A microammeter gives a full scale deflection for a current of 100 fjA and has a resistance of 1 000 **Ω**. What resistor is needed to convert it into a voltmeter reading to (a) 10 V, (b) 100 V, and how must the resistor be connected?

27 ELECTROLYSIS

[Where necessary refer to the list of values on page 4]

27.1 What mass of copper will be deposited by passing a current of 1.0 A through a copper voltameter for 1.0 hour?

27.2 What mass of nickel will be deposited by passing a current of 2.0 A through a nickel voltameter for 2.0 hours.

27.3 How long will it take to deposited by passing of copper in a copper voltameter which carries a current of 3.0 A?

27.4 How long will it take to deposit 120 mg of nickel in a nickel voltameter which carries a current of 2.5 A?

27.5 An ammeter, connected in series with a copper voltameter and a suitable electricity supply, reads 2.1 A. At the same time it is found that 330 mg of copper are deposited in 500 s. What is the error in the ammeter reading?

27.6 An ammeter, connected in series with a silver voltameter and a suitable electricity supply reads 0.55 A. At the same time it is found that 112 mg of silver are deposited in 200 s. What is the error in the ammeter reading?

27.7 How long will it take to deposit a 0.10 mm thick layer of a metal of density 7 200 kg/m^3 and e.c.e. 0.000 000 50 kg/C on both sides of a plate, of area 2 000 mm^2, which forms the cathode of a suitable voltameter, if the current used is 2.0 A?

27.8 How long will it take to deposit a 0.2 mm thick layer of a metal of density 10800 kg/m^3 and e.c.e. 0.000 000 25 kg/C on both sides of a plate, of area 4 000 mm^2, which forms the cathode of a suitable voltameter, if the current used is 5.0 A?

27.9 How long will it take to release 0.002 2 m^3 of hydrogen from a water voltameter, if a currant of 2.0 A is used? Take the density of hydrogen as 0.090 kg/m^3 under the conditions of the experiment.

28.9 How long will it take to release 0.000 33 m^3 of hydrogen from a water voltameter, if a curium of G.O A is used? Take the density of hydrogen as 0.090 kg/m^3 under the conditions of the experiment.

27.11 Calculate the e.c.e. of a metal if a mass of 0.12 g is deposited by a current of 0.5 A in 20 minutes.

27.12 Calculate the e.c.e. of a metal if a mass of 0.27 g is deposited by a current of 1.5 A in 20 minutes.

27.1 3 A copper and a zinc voltameter are joined in series. If *a* mass of 0.477 g of copper is deposited, find the mass of zinc deposited by the same quantity of electricity. Take the relative atomic mass of copper to be 63.6 and of zinc to be 65.4. Both metals are in a divalent form.

27.14 A nickel and a silver voltameter are joined in series. If a mass of 0.196 g of nickel is deposited, find the mass of silver deposited by the same quantity of electricity. Take the relative atomic mass of nickel to be 58.8 and of silver to be 108. Nickel is in *a* divalent form and silver a divalent form and silver a monovalent form.

28 HEATING EFFECT COST

[Where necessary refer to the list of values on page 4]

28.1Find the amount of electrical energy converted into heat energy in a resistor carrying a current of 10 A for 5.0 minutes.The p.d across the resistor is 4.0 V.

28.2 A p.d of 6.0 V is developed across a resistor carrying a current of 8.0 A. How much electrical energy is converted into heat energy in 4.0 minutes?

28.3 A coil of resistance 8.4Ω and of negligible thermal capacity is immersed in 800 g of water. How long does it take for the temperature of the water to rise from $18\,^0\mathrm{C}$ to $43\,^0\mathrm{C}$, if a current of 5.0 A is passed through the coil?

28.4 A coil of resistance 21Ω and of negligible thermal capacity is immersed in 3.0 kg of water. How long does it take for the temperature of the water to rise from 15 ^{0}C to 45 ^{0}C ,if a current of 6.0 A is passed through the coil?

28.5 A coil of resistance 10Ω is immersed in water. A p.d of 150 V is applied across the coil. How long does it take to boil away 100g of water, once the water has started to boil?

28.6 A coil of resistance 30Ω is immersed in water A p.d. of 45 V is applied across the coil. How long does it take to boil away 100g of water, once the water has started to boil?

28.7 What is the power of an immersion heater which can raise the temperatue of 2.4 kg of water through 10K in 5 minutes?

28.8 What is the power of an immersion heater which will raise the temperature of 1.2 k of water from 15 ^{0}C to 60 ^{0}C in 15 minutes?

28.9 A heater is marked 2.0 Kw 250 V. Assuming this to be correct and the resistance of the device not to change, what power would be developed if the heater is connected to a 200 V supply?

28.10 An electric kettle is marked 3.0 kW 250 V. Assuming that this is correct and that the resistance of the element is constant. Calculate the power developed in the kettle when it is connected to a 225 V supply.

28.11 How much does it cost to use a 2.0 Kw electric fire for 10 hrs at two pence per unit?

28.12 How much does it cost to use a 3.0 Kw immersion heater for 20 hrs at a penny per unit?

28.13 A heater takes a current of 8.0 A from a 240 V supply. Calculate (a) it's resistance, (b) the power developed, and (c) the cost of using the device for 20 hrs at 1.5 pence per unit.

28.14 A projector bulb takes a current of 2.0 A from a 250 V supply. Calculate (a) its resistance, (b) the power developed and (c) the cost of using the bulb for a film show lasting 2.0 hours at two pence per unit.

29 HALF-LIFE; RADIOACTIVITY

29.1 a Gieger-Muller tube sealed into a container of radio- active gas and connected to a scaler, records a count of 1200 per second at 8:00 a.m on Monday, and of 300 per second at noon on the following Wednesday. Estimate the half-life of the gas.

29.2 A radio-active counting system records a count of 3 200 per second for a particular radioactive source at 10.00 a.m on Monday and 400 per second at noon on Monday and 400 per second at 1.00 p.m on the next day. Estimate the half-life of the source.

29.3 A particular radio-active source has a half-life of 2.0 hours. A sample gives a count of 2 400 per second at 11.00 a.m. When will the count have dropped to approximately 300 per second in the same counting system?

29.4 One radioactive isotope of silver has a half –life of 20 minutes. A sample fixed in a counting system gives a count of 6 400 per second at noon. When will the count have dropped to approximately 200 per second?

29.5 The radioactive nuclide $^{216}_{84}$Po emits an alpha particle. Calculate the mass number and atomic number of the nuclide of lead which is formed and write the nuclear equation?

29.6 The radioactive nuclide $^{177}_{71}$Lu emits a beta particle. Calculate the mass number and atomic number of the nuclide of Hafnium which is formed and write the nuclear equation.

B FULL SOLUTIONS

(odd numbered problems only)

1.1 The volume of the rectangular block

= length x breadth x depth

= 3 x 2 x 1

= 6 m^3

As density $= \dfrac{\text{mass}}{\text{volume}}$

$= \dfrac{24000}{6}$

$= 4\ 000\ \text{kg/m}^3$

1.3 As volume $= \dfrac{\text{Mass}}{\text{density}}$

$= \dfrac{1.76}{7000}\text{m}^3$

Also volume $= \pi \times \left(\dfrac{\text{diameter}}{2}\right)^2 \times \text{length}$

$= \pi \times \left(\dfrac{0.040}{2}\right)^2 \times \ell$

$\therefore \pi \times (0.020)2 \times \ell = \dfrac{1.76}{7000}$ (Take $\pi = \dfrac{22}{7}$)

$\therefore \qquad \ell = \dfrac{7 \times 1.76}{22 \times 7000 \times (0.020)^2}$

$= 0.20\ \text{m}$

1.5 As volume $= \dfrac{\text{mass}}{\text{density}}$

The volume of metal present is given by $\dfrac{7.2}{8000}$

$= 0.000\ 90\ \text{m}^3$

The outside volume of the cube $= (\text{length of side})^3$

$= (0.10)^3$

$= 0.001\ 00\ \text{m}^3$

The pore volume = outside volume – metal volume

$= 0.001\ 00 - 0.00090$

$= 0.000\ 10\text{m}^3$

1.7 As mass = volume x density

Mass of water Present = 0.000 300 x 1 000

= 0.300 kg

And mass of liquid Present = 0.000 200 x 1500

= 0.300 kg

$\therefore$ Total mass Present = 0.300 + 0.300

= 0.600 kg

As no change in volume on mixing, the total volume

= 0.000 300 + 0.000 200

= $0.000\ 500\ \text{m}^3$

So mixture density $= \dfrac{\text{total mass}}{\text{total volume}}$

$= \dfrac{0.600}{0.000500}$

= 1200 kg/m^3

1.9 Assume 1 unit (of volume) of water is mixed with v units (of volume) of alcohol Then mass of water = volume x density

= 1 x 1 000

And mass of alcohol = v x 800

:. Total mass = 1 000 + 800 v

Total volume, as no change on mixing = 1 + v

So mixture density $= \dfrac{\text{total mass}}{\text{total volume}}$

:. $850 = \dfrac{1000+800v}{1+v}$

$\therefore$ 850 + 850 v = 1000 + 800 v

$\therefore$ 50 v = 150

v = 3

So (a) 1 unit (of volume) of water to 3 units (of volume) of water gives 1 000 units of mass and 3 units (of volume) of alcohol gives 2 400 units of mass. So (b) 1 unit (of mass) of water to 2.4 units (of mass) of alcohol.

1.11,, As volume $= \dfrac{\text{mass}}{\text{density}}$

Volume of liquid $= \dfrac{0.200}{800}$

= $0.000\ 25\ \text{m}^3$

= volume of bottle

$= \dfrac{0.160}{3200}$

= $0.0000\ 05\text{m}^3$

Volume of water = Volume of bottle - volume of sand

= 0.00025 – 0.000 05

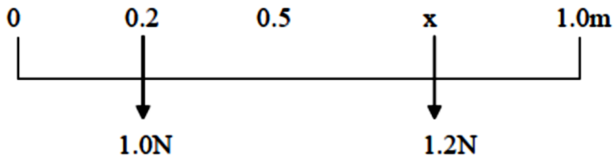
= $0.000\ 20\text{m}^3$

Mass of water = volume x density

= 0.000 20 x 1000

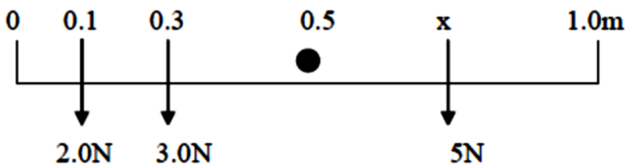
= 0.20 kg = 200g

2.1 Let the 1.2 N weight be hung a distance x along the rule. Take moments about the centre of the rule.



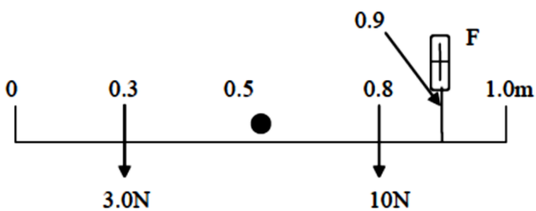
Moment due to 1.0 N force = 1.0 x 0.3 (A.C.W.)
Moment due to 1.2 N force = 1.2 x (x – 0.5)(C.W)
By the principle of moments, the rule is in equilibrium.
A.C.W, moment = C.W. moment
:. 1.0 x 0.3 = 1.2 x (x – 0.5
:. 0.3 = 1.2x – 0.6
:. 1.2x = 0.9
:. **x = 0.75 m**

2.3 The 5.0 N weight be hung a distance x along the rule. Take moments about the centre of the rule.



Moment due to 2.0 N force = 2.0 x 0.4 (A.C.W.)
Moment due to 3.0 N forces = 3.0 x 0.2 (A.C.W.)
Moment due to 5.0 N force = 5.0 x (x – 0.5) (C.W.)
By the principle of moments, as the rule is in equilibrium total A.C.W moment = C.W. moment.
:. 2.0 x 0.4 + 3.0 x 0.2 = 5.0 x (x – 0.5)
:. 0.8 + 0.6 = 5.0x – 2.5
:. 5.0x = 3.9
:. **x = 0.78 m**

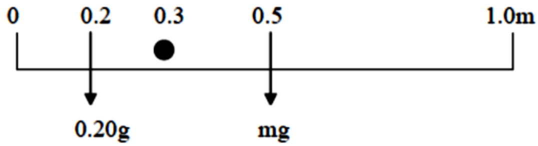
2.5 Let the reading on the spring balance b F. Take moments about the centre of the rule.



Moment due to 3.0 N force = 3.0 x 0.2 (A.C.W.)

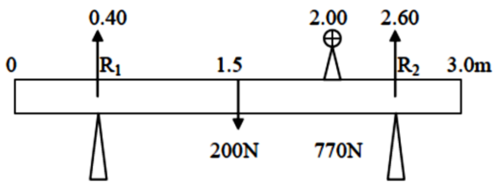
By the principle of moments, as the rule is in equilibrium
Total A.C.W. moment = C.W. moment
:. $3.0 \times 0.2 + f \times 0.4 = 10 \times 0.3$
:. $0.6 + 0.4\,F = 3.0$
:. $0.4\,F = 2.4$
:. $F = 6.0$ N

2.7 Let the mass of the rule be m so the weight is mg. It acts at the mid-point as the rule is uniform. Take moments about the 30 cm mark.



Moment due to 0.20 g force = 0.20 g x 0.1 (A .C.W.)
Moment due to mg = mg x 0.2 (C.W.)
By the principle of moments, as the rule is in equilibrium.
A.C.W moment = C.W. moment
$0.20\,g \times 0.1 = mg \times 0.2$
:. $0.020 = 0.2\,m$
:. $m = 0.\,10$ kg
= 100 g

2.9 Let the reactions be R_1 and R_2 as shown. Take moments about the 0.40 m mark (so eliminating R_1 from the resulting equation).
Moment due to 200 N force = 200 x 1.10 (C.W.)
Moment due to 770 N force = 770 x 1.60 (C.W.)



Moment due to R_2 = $R_2 \times 2.20$ (A.C.W.)
By the principle of moments, as the system is in equilibrium
Total C.W. moments = A.C.W moment :. $200 \times 1.10 + 770 \times 1.60$
$= R_2 \times 2.20$
(divide through by 1.10)
:. $200 + 700 \times 1.60 = R_2 \times 2.20$
(divide through by 1.10
:. $200 + 700 \times 1.60 = 2R_2$
:. $200 + 1120 = 2R_2$
:. $2R_2 = 1320$

:. = 660 N

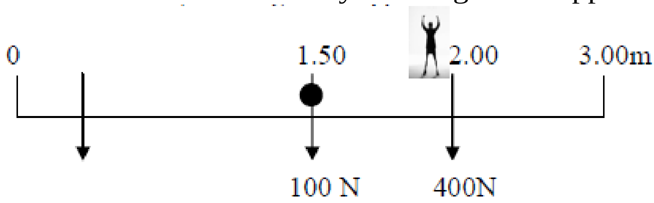
And as the plank is in equilibrium the total upward force

= total downward force

:. $R_1 + 660 = 200 + 770$

:. $\underline{\mathbf{R_1 = 310\ N}}$

2.11 As the plank is uniform its weight acts at its mid-point. Let John walk as far as x before the system begins to topple.



Take moments about the 2.00 m position. Moment due to 100 N force.

= 100 x 0.50 (A.C.W.)

Moment due to 400 N force = 400 x (x – 2.00) (C.W.)

By the principle of moments, at the system is in equilibrium A.C.W. moment = C.W. moment

:. 100 x 0.50 = C.W, moment

:. 50 = 400 x (x – 2.00)

:. 400x = 850

:. x = 2.125 m

:. John can walk out a distance of 2.125 -2.00

= **<u>0.125 m</u>**

2.13 Let the left hand arm of the balance have length a and the right hand arm length b. If the unknown mass in m, then by the principle of moments, as the balance is in equilibrium.

$mga = 1.060\, g\, b$

and $1.142\, g\, a = mg\, b$

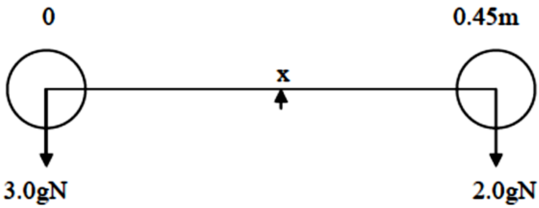
Divide $\dfrac{m}{1.142} = \dfrac{1.060}{m}$

$m^2 = 1.060 \times 1.142$

$= 1.210$

$m = \underline{\mathbf{1.100\ kg}}$

2.15 By symmetry the C. of G, must be in the rod joining the centre of the spheres. As the system would balance on a pivot placed below the C. of G. imagine such a pivot placed at x as shown



Take moments about the pivot Moment due to 3.0 g force

= 3.0 g x (A.C.W)

Moment due to 2.0 g (0.45 – x) (C.W.)

By the principle of moments, as the system would be in equilibrium

A.C,W, moment = C.W. moment

:. 3.0 g x = 2.0 g to (0.45 – x)

:. 3.0 x = 0.90 – 2.0 x

:. 5.0 x = 0.90

:. **x** = **0.18 m**

:. C, of G. is 0.18 m from centre of 3.0 kg sphere along line joining the centres.

2.17 Let the weight per unit area of the material of the disc be w.

Then the weight of the complete disc is $\pi\ (0.028)^2$ w and would act vertically downwards at the centre. Also the weight of the part which is removed is π (0.0007)2 w and this can be treated as an upward force as far as the system is concerned.

By symmetry the C. of G. of the "remainder" must be on the joining the centres and it must be to the left

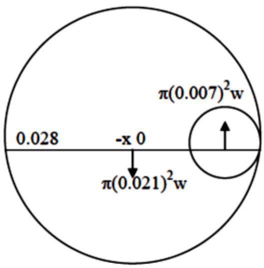


Fig. 8

(Fig. 8) of the original centre so that the two forces may balance about it.

Take moments about the C. of G. Moment due to π (0.028)2 w force

$= \pi\ (0.028)^2$ wx (C.W.)

Moment due to $\pi\ (0.007)^2$ w force $= \pi\ (0.007)^2$ w (x + 0.021) (A.C.W.)

By the principle of moments, as the system is in equilibrium

C.W. moment = A.C.W. moment

:. $\pi\ (0.028)^2$ wx $= \pi\ (0.007)^2$ w (x + 0.021)

Divide through by π (0.007)2 w

:. 16x = x + 0.021

:. 15x = 0.021

:. x = 0.0014 m

:. C. of G. of remainder is 1.4 mm from centre of disc on the opposite side to the hole, on the line joining the centres of the disc and hole.

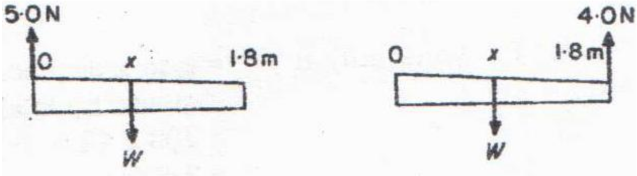


Fig. 9

2.19 Let the weight of the rod be W and the position of the C. of G. x from the end where the 5.0 N force is applied. First take moments about the right hand end. Moment due to 5.0 N force = 5.0 x 1.8 (C.W) . Moment due to W = W x (1.8 – x) (A.C.W) By the principle of moments, as the system is in equilibrium C.W. moment = A.C.W. moment

:. 5.0 x 1.8 = W (1.8 – x)

= 1.8 W – Wx – (1)

Then take moments, etc, about the left hand end for the second case, as before 4.0 x 1.8 = Wx -(20

Add (1) and (2)

:. 5.0 x 1.8 + 4.0 x 1.8 = 1.8 W

:. W = 9.0 N

Substitute in (2)

:. 4.0 x 1.8 = 9.0x

:. x = <u>0.8 m</u>

So weight of rod is 9.0 N and the C. of G. is 0.8 m from the end where a 5.0 N force is needed.

3.1 Either

$$\text{Mechanical advantage} = \frac{\text{load}}{\text{effort}}$$

$$= \frac{200}{50} = 4$$

$$\text{Velocity ratio} = \frac{\text{dis tance moved by effort}}{\text{dis tance movedby load}}$$

$$= \frac{30}{6.0} = 5$$

And efficiency $= \dfrac{\text{mechanical advantage}}{\text{velocity ratio}}$

$$= \frac{4}{5} = 80\%$$

Or

Work done by effort = effort x distance moved by effort

= 50 x 30

= 1 500 J

Work done on load = load x distance moved by load

= 200 x 6.0

= 1 200 J

and efficiency $= \dfrac{\text{work done on load}}{\text{work done by effort}}$

$$= \frac{1200}{1500} = \frac{4}{5} = 80\%$$

3.2 For pulley system see the diagram

Fig 10

As efficiency $= \dfrac{\text{mechanical advantage}}{\text{vellocity ration}}$

$$\frac{75}{100} = \frac{\text{m.a}}{4}$$

:. M.a. $= \dfrac{4 \times 75}{100}$

but m.a. $= \dfrac{\text{load}}{\text{effort}}$

:. $3.0 = \dfrac{450}{\text{effort}}$

:. effort = 150 N

3.3 For pulley system see the diagram.

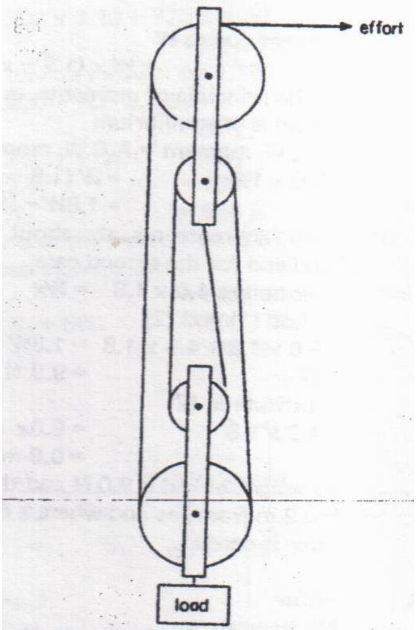


Fig. 10

As effeciency $= \dfrac{\text{mechanical advantage}}{\text{velocity ratio}}$

$\dfrac{75}{100} = \dfrac{\text{m.a}}{4}$

:. m.a $= \dfrac{4 \times 75}{100}$

$= 3.0$

But m.a $= \dfrac{\text{load}}{\text{effort}}$

:. 3.0 $= \dfrac{450}{\text{effort}}$

:. $=$ 150N.

3.5 For a screw,

Velocity ratio $= \dfrac{2\pi \text{ x length of effort arm}}{\text{pitch}}$

$= \dfrac{2\pi \text{ x } 0.070}{0.001}$ (take $\pi = \dfrac{22}{7}$

$$= \frac{2 \times 22 \times 0.070}{7 \times 0.001}$$

$= 440$

and mechanical advantage = velocity ratio x efficiency

$$= 440 \times \frac{40}{100}$$

$= 176$

but mechanical advantage $= \frac{\text{load}}{\text{effort}}$

:. $176 = \frac{\text{load}}{10}$

:. Load = 1760 N

= 1800 N (t0 2 fig.)

3.7 For an inclined plane $= \frac{\text{slopelength}}{\text{verticalrise}}$

$$= \frac{3.0}{1.0}$$

$= 3.0$

As mechanical advantage = Velocity ratio x efficiency

$$= 3.0 \times \frac{80}{100}$$

$= 2.4$

but mechanical advantage $= \frac{\text{load}}{\text{effort}}$

:. $2.4 = \frac{480}{\text{effort}}$

:. effort $= \frac{480}{2.4}$

3.9 work done per second

= load x distance

Moved per second

= 100 x 2.0

= 200 W

Engine output
Power = 500 W

And efficiency $= \frac{\text{work done per second}}{\text{engine output power}}$

$$= \frac{200}{500}$$
$= 0.4$
$= 40\%$

3.11 Work output = load x distance
Moved by load
$= 200 \times 12.0$
$= 2400$ J

And as work input $= \frac{\text{work output}}{\text{efficiency}}$

$$= \frac{2400 \times 100}{60}$$
$= 4\ 000$ J

As loss = input – output
$= 4000 - 2400$
= 1600 J

3.13 The weight of the lower pulley block must be taken with the load mechanical advantage $= \frac{\text{load}}{\text{effort}}$

$$= \frac{600}{150}$$
$= 4.0$

And efficiency $= \frac{\text{mechanical advantage}}{\text{velocity ratio}}$

$$= \frac{4.0}{5.0}$$
$= 0.8$
$= 80\%$

So 20% of the effort is wasted.

4.1 The greatest pressure that the block can produce when resting on a level, horizontal floor occurs when it rests on its smallest face.

Pressure $= \frac{\text{weight}}{\text{area}} = \frac{\text{mass} \times g}{\text{area}}$

$$= \frac{3000 \times 9.8}{2.0 \times 0.1}$$
$= 147000$ N/m^2

= 150 kN/m^2 (to 2 fig.)

4.3 As pressure = depth x density x g

Water pressure = atmospheric + water

= 101333 N/m^2

= 101.(3) kN/m^2 (to 3 fig)

The mercury pressure must equal the water pressure as atmospheric pressure does not change.

Let the difference between the mercury level be x

:. X x 13 600 x g = 0.136 x 1000 x g

$$= \frac{0.136 \times 1000}{13600}$$

= 0.010 m

= 10 mm

4.5 As the pressure due to the column of oil AB is equal to the pressure due to the column of water C.D, and pressure = depth x density x g

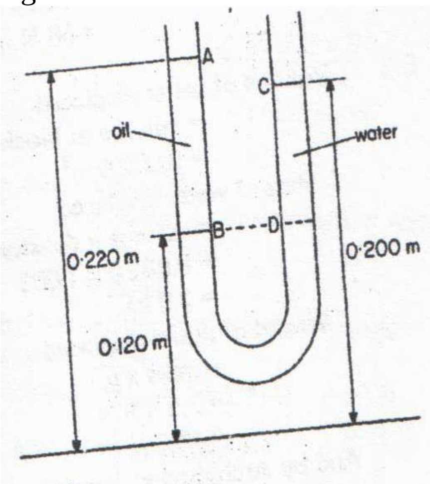


Fig. 11

Let p = density of oil

:. (0.220 – 0.120) x p x g = (0.200 – 0.120) x 1000 x g

:. 0.100 p = 0.080 x 1000

$$:. \quad P = \frac{0.080 \times 1000}{0.100}$$

= 800 kg/m^3

4.7 Pressure change recorded by barometer = change in height x density of Mercury x g = (0.756 - 0.696) x 13600 x g

Change in air pressure = change in height x density of air x g

= h x 1.20 x g

Where h = height of mountain

But these are equal pressure changes

:. (0.756 – 0.696) x 13600 x g = h x 1.20 x g

:. 0.060 x 13 600 = h x 1.20

:. H = <u>680 m</u>

5.1 Volume of liquid displaced = volume of liquid displaced

= $\frac{1}{2}$ x 0.0020

= 0.0010m^3

:. Mass of liquid displaced = volume x density

= 0.0010 x 1200

= 1.2 kg

:. Weight of liquid displaced = mass x g

= 1.2 x 9.8

And by Archimedes principle = upthrust

But upthrust = weight in air – weight

In liquid

:. 1.2 x 9.8 = 80 – weight in liquid

:. Weight in liquid displaced = 98 N

:. Mass of liquid = $\frac{98}{9.8}$ = 10 kg

For water, volume of water displaced = $\frac{\text{mass}}{\text{density}}$

= $\frac{10}{1000}$

= 0.010 m^3

But solid is the quarters immersed

:. Volume of solid = $\frac{4}{3}$ x volume of water displaced

= $\frac{0.010 \text{x} 4}{3}$

And mass of solid = $\frac{\text{weight}}{\text{g}}$

= $\frac{196}{9.8}$

$= 20$ kg

:. Density of solid $= \dfrac{\text{mass}}{\text{volume}}$

$= \dfrac{20 \times 3}{0.010 \times 4}$

$=$ **1500 kg/m^3**

For other liquid, volume of liquid displaced $= \frac{1}{2}$ volume of solid

$= \dfrac{0.010 \times 4}{2 \times 3}$

:. Density of liquid $= \dfrac{\text{mass}}{\text{volume}}$

$= \dfrac{10 \times 2 \times 3}{0.010 \times 4}$

$=$ **1500 kg/m^3**

5.11 In water, upthrust = weight in air – weight in water

$= 392 - 294$

$= 98$ N

And by Archimedes, principle = weight of water displaced

:. Weight of water displaced $= 98$ N

:. Mass of water displaced $= \dfrac{\text{weight}}{g}$

$= \dfrac{98}{9.8}$

$= 10$ kg

:. Volume of water displaced $= \dfrac{\text{mass}}{\text{density}}$

$= \dfrac{10}{100}$

As solid is totally immersed in water Volume of solid.

= Volume of water displace

$= 0.010\text{m}^3$

As solid is half immersed in liquid Volume of liquid displaced

$= \frac{1}{2}$ x volume x density

$= 0.005$ m3

:. Mass of liquid displaced = Volume x density

$= 0.005 \times 1200 = 6.0$ kg

:. Weight of liquid displaced
= mass x g
= 6.0 x 9.8
= 58.8 N
And by Archimedes' principle, = upthrust .
But upthrust = weight in air – weight in liquid
:. 58.8 = 392 – weight in liquid
:. Weight in liquid = 392 – 58.8
= 333.2
= 333 N (to 3 fig.)

5.13 By the principle of moments, as the rule in in equilibrium
Weight of metal x distance to pivot = balancing weight x distance to pivot
:. Weight of metal × 0.50 = 50 x 0.25
:. Weight of metal = 25
When immersed in water volume of water displaced
= volume of solid
= 0.0010 m^3
:. Mass of water displaced = Volume x density
= 0.0010 x 1000
= 1.0 kg
:. Weight of water displaced = mass x g
= 1.0 x 9.8
= 9.8 N
And by Archimedes' principle, = upthrust
But upthrust = weight in air - weight in water
:. 9.8 = 25 – weight in water
:. Weight in water = 25 – 9.8
= 15.2 N
Then by the principle of moments, if ℓ = new length to balance weight,
3s before 15.2 x 0.50 = 50 x ℓ
ℓ =0.152 m and this corresponds to 65. [2] cm mark on rule

5.15 Let the volume of the wood be V.
:. Volume of water displaced = $\frac{3}{4}$ x volume of wood
= 0.75 V
:.Mass of water displaced = volume x density
= 0.75 V x 1000
= 750 v
:. Weight of water displaced = mass x g
= 750 V x 9.8
And by principle of flotation,
:.Weight of wood = 750 V x 9.8

:. Mass of wood $= \dfrac{\text{wight}}{g}$

$= \dfrac{750V \times 9.8}{9.8}$

$= 750\ V$

:. Density of wood $= \dfrac{\text{mass}}{\text{Volume}}$

$= \dfrac{750\ V}{V}$

$= \mathbf{750\ kg\ /m^3}$

5.17 Let the length of the stem immersed be ℓ

:. Volume of hydrometer immersed

= volume of bulb + volume of stem immersed

$= 0.000020 + 0.00010\ \ell$

:. Volume of water displaced

= volume of hydrometer immersed

$= 0.000020 + 0.000\ 10\ \ell$

:. Mass of water displaced

= volume x density

$= (0.000020 + 0.00010\ \ell) \times 1000$

$= 0.020 + 0.10\ \ell$

:. Weight of water displaced = mass x g

$= (0.020 + 0.10\ \ell\ ) \times 9.8$

And by principle of flotation, = weight of hydrometer

:. Weight of hydrometer

$= (0.020 + 0.10\ \ell) \times 9.8$

:. Mass of hydrometer $= \dfrac{\text{weight}}{g}$

$= \dfrac{(0.020 + 0.10\lambda) \times 9.8}{9.8}$

$= 0.020 + 0.10\ \ell$

But is given as $= 0.035$

:. $0.020 + 0.10\ \ell = 0.035$

:. $0.10\ \ell = 0.015$

$\boldsymbol{\ell = 0.15\ m}$

5.19 Volume of sea water displaced, when raft is just totally immersed,

= volume of raft

$= 10m^3$

:. Mass of sea water displaced = volume x density

= 10 x 1020

= 10 200 kg

:. Weight of seawater displaced

= mass xg

= 10200 x 9.8

And by the principle of flotation, = weight of raft + load

:. Weight of raft + load = 10200 x 9.8

:. Mass of raft + load = $\frac{\text{weight}}{g}$

= $\frac{10200 \times 9.8}{9.8}$

= 10200 kg

But raft has mass = volume x density

= 10 x 550

= 5 500 kg

:. Mass of load = 10200 – 5500

= 4700 kg

5.20 If bottle is just to sink, volume of liquid displaced

= volume of bottle

= 0.0010 m^3

:. Mass of liquid displaced = volume x density

= 0.0010 x 1100

= 1.1 kg

:. Weight of liquid displaced = mass x g

= 1.1 x 9.8

And by principle of flotation = weight of bottle + contents

= 1.1 x 9.8

:. Mass of bottle + contents = $\frac{\text{weight}}{g}$

= $\frac{1.1 \times 9.8}{9.8}$

= 1.1 kg

As mass bottle = 0.20 kg

:. Mass of contents = 1.1 – 0.2

= 0.9 kg

5.23 Let volume of metal required be V Then, as bottle + metal just sinks, total volume of liquid displaced

= volume of bottle + volume of metal

= 0.0030 + v

:. Mass of liquid displaced = volume x density

= (0. 0030 + V) x 800

= 2.4 + 800 V

:. Weight of liquid displaced = mass x g

= (2.4 + 800 V) x 9.8

And by principle of flotation = weight of bottle + metal

:. Weight of bottle + metal = (2.4 + 800 V) x 9.8

:. Mass of bottle + metal = $\frac{\text{weight}}{g}$

= $\frac{(2.4+800V)\,x\,9.8}{9.8}$

= 2.4 + 800 V

But mass of bottle = 1.0 kg

:. Mass of metal = 1.4 + 800 V

But also, = Volume x density

= V x 5000

:. 5 000 V = 1.4 + 800 V

:. 4200 V = 1.4

:. 3000 V = 1.0

V = 0.000 333 m^3

:. Mass of metal = volume x density

= 0.000 333 x 5000

= 1.66 kg

= 1.7 kg (to 2 fig.)

5.25 Volume of air displaced = volume of balloon

= $100m^3$

:. Mass of air displaced = volume x density

= 100 x 1.29

= 129 kg

:. Weight of air displaced = mass x g

= 129 x 9.8 = upthrust

(By Archimedes' principle)

But as balloon is tethered Upthrust = weight of balloon + weight of hydrogen + tension in cable

(volume of hydrogen = $100m^3$

:. Mass of hydrogen = volume x density = 100 x 0.09 = 9 kg

:. Weight of hydrogen = mass x g

= 9 x 9.8)

:. 29 x 9.8 = 50 x 9.8 + 9 x 9.8 + tension

:. Tension = (129 – 50 – 9) x 9.8

= 70 x 9.8

= 686

= 690 N (to 2 fig.)

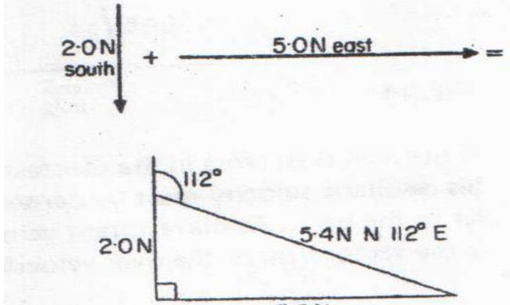


Fig. 12

6.1 Draw a vertical line (to scale) to represent the 2.0 N force acting south. From where that finishes draw a horizontal line to represent the 5.0 N force acting east. Join start and finish to find resultant, which is 5.4 N at N 112^0E

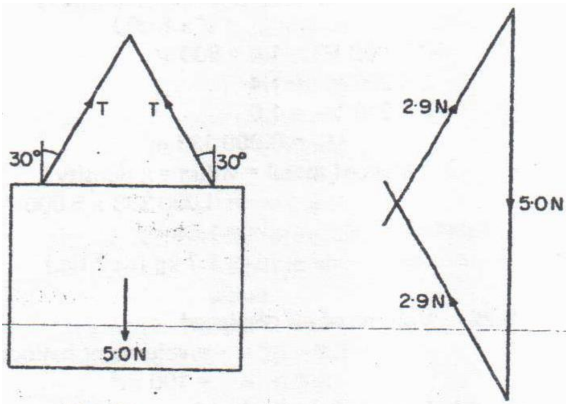


Fig. 13

6.3 As the picture is in equilibrium, the three forces must make a complete vector triangle. Draw a vertical line (to scale) to represent that 5.0 N weight. Draw lines from top and bottom of this, in direction of tensions, until these meet, giving a closed triangle.
Measure the tensions, which are both 2.9 N.

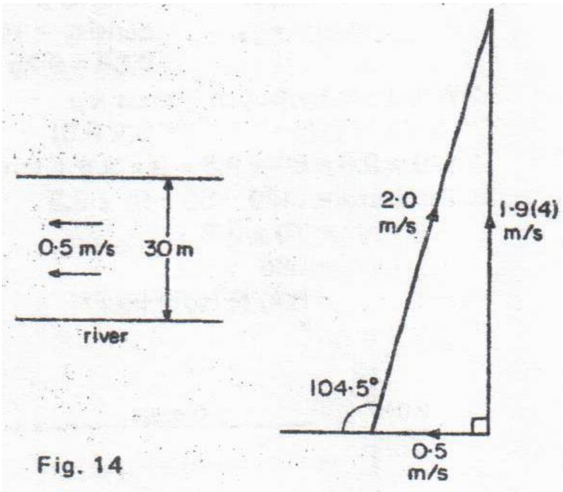


Fig. 14

6.4 If the man is to cross in the short test time, his resultant velocity must be perpendicular to the bank. As his resultant velocity is the vector sum of the river velocity boat velocity, draw (to scale) the river velocity, say horizontal as shown, Now draw in the resultant direction from the start of the river velocity vector. Then put in the boat velocity vector from the end of the river velocity vector to finish on the resultant vector line.
Hence put in the resultant vector, measure the angle to steer which is 104.50 from the direction of the river flow.
As resultant speed is 1.94 m/s

Time to cross $= \dfrac{30}{1.94} = 15.46$

$= 15.(5)$ s (to 2 fig.)

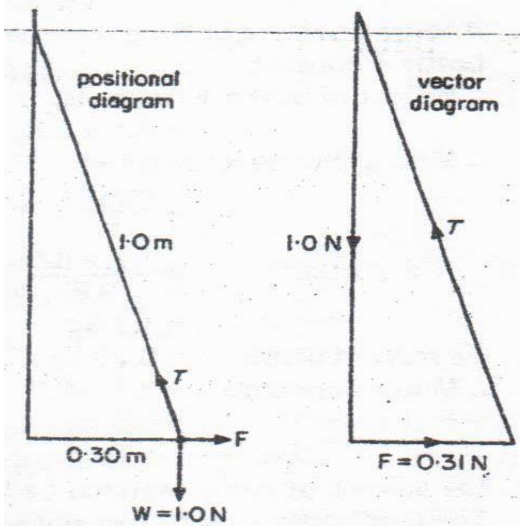


Fig. 15

6.7 First draw a scale positional diagram of the system (left hand diagram). Note the angle made by the cord to the vertical (17.5^0). Now draw the vector diagram. First draw a vertical line (to scale0 to represent the weight (of 1.0 N). Then draw in the position of the T and F zontal) until they meet. This gives a closed triangle as the system is in equilibrium, i.e has no resultant.
Measure the value of F, which is 0.31 N.

7.1 Each ten take 0.1 s

So in first time period average speed $= \dfrac{\text{distance}}{\text{time}} = \dfrac{0.170}{0.1}$

$=1.70$ m/s

$$= \frac{0.270}{0.1}$$

$$= 2.70 \text{ m/s}$$

Now average acceleration `$= \dfrac{\text{change in speed}}{\text{time taken}}$ (Now time taken is 0.1 s as it must be from middle of first period to middle of second)

:. Acceleration $= \dfrac{2.70-1.70}{0.1}$

$\underline{= \quad \mathbf{10\ m/s^2}}$

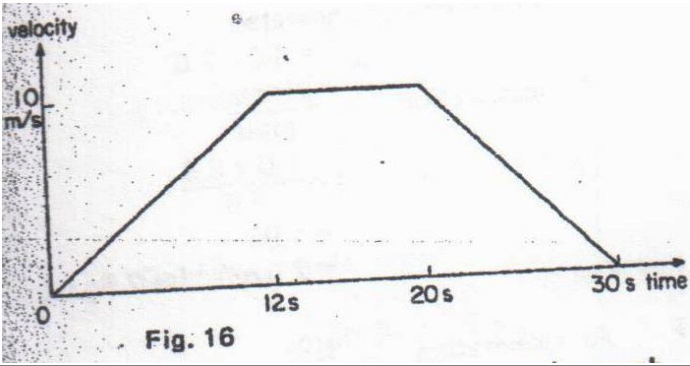


Fig. 16

7.3 distance traveled = area under graph

(i.e area of trapezium)

$$= \frac{30+8}{2} \times 10$$

7.5 As acceleration $= \frac{\text{change in speed}}{\text{time taken}}$

$$= \frac{25-10}{10}$$

$$\underline{= \quad \mathbf{1.5\ m/s^2}}$$

7.7 Either (from first principles)

Let final speed be v and time during which it travels the 70 m be t.

Then as acceleration $= \frac{\text{change in speed}}{\text{time taken}}$

$$1.25 = \frac{v-15.0}{t}$$

.: $v = 15.0 + 1.25\,t$

And average speed $= \frac{\text{initial speed} + \text{final speed}}{2}$

$$= \frac{150.0 + 15.0 + 1.25t}{2}$$

$$= 15.0 + 0.625\,t$$

= average speed x time

:. $70 = (15.0 + 0.625\,t)\,t$

:. $0.625t^2 + 15.0t - 70 = 0$

:. $t^2 + 24.0t - 70 = 0$

:. $t^2 + 24.0t - 112 = 0$

$\therefore (t - 4)(t + 28) = 0$

$\therefore t = 4$ s

And $v = 15.0 + 5.0$

$= 20.0$ m/s

Or using equations of uniformly accelerated motion)

V = final speed a = acceleration

U = initial speed s = distance traveled

Use $v^2 = u^2 + 2\,as$

$\therefore v^2 = 15.0^2 + 2 \times 1.25 \times 70$

$= 225 + 175$

$= 400$

$v = 20.0$ m/s

7.9 Either (from first principles)

Let t = time during which ball is rising

As acceleration = $\dfrac{\text{change in speed}}{\text{time taken}}$

$\therefore 9.8 = \dfrac{14.7}{t}$

$\therefore T = \dfrac{14.7}{9.8}$

$= 1.5$ s

And average speed $= \dfrac{\text{initial speed} + \text{final speed}}{2}$

$= \dfrac{14.7 + 0}{2}$

$= 7.35$ m/s

So distance traveled = average speed x time

$= 7.35 \times 1.5$

$= 11.025$

$= 11.0$ m (to 3 sig fig.)

Or using equations of uniformly acceleration motion)

V = final speed a = acceleration

U = initial speed s = distance traveled

Use $v^2 = u^2 + 2as$

$\therefore 0 = 14.72 - 2 \times 9.8 \times s$

$\therefore 19.6s = 216$

$s = 11.03$

= 11.0 m (to 3 fig.)

7.11 Either (from first principles)

Let speed at impact = v

As acceleration = $\frac{\text{change in speed}}{\text{time taken}}$

:. 9.8 = $\frac{8.0 + v}{5.0}$

(take downwards as positive)

:. 49 = 8.0 + v

:. v = 41 m/s

:. Average speed = $\frac{\text{intital speed} + \text{final speed}}{2}$

= $\frac{-8 + 41}{2}$

= 16.5 m/s

:. Distance fallen = average speed x time

= 16.5 x 50

= 82.5 = height of helicopter

:. Height of helicopter = 83 m (to 2 fig.)

Or (using equations of uniformly accelerated motion)

S = distance travelled a = acceleration

U = initial speed r = time taken

Use s = ut + $\frac{1}{2}$ at^2

Take downwards as positive.

:. S = -8 x 5 + $\frac{1}{2}$ x 9.8 x 52

= - 40 + 4.9 x 25

= -40 + 122.5

= 82.5

= 83 m (to 2 fig.)

8.1 As force = mass x acceleration

2.0 = 5.0 x acceleration

:. Acceleration = 0.4 m/s^2

And acceleration = $\frac{\text{change in speed}}{\text{time taken}}$

:. 0.4 = $\frac{\text{final speed} - 0}{3.0}$

:. **Final speed = 1.2 m/s**

8.3 Force acting on whole system

= weight of 5.0 kg mass

But weight = mass x g

:. Force = 5.0 x 9.8

And mass being accelerated

= 3.0 + 5.0

As acceleration $= \frac{\text{force}}{\text{mass}}$

$= \frac{5.0 \times 9.8}{8.0}$

= 6.125

= 6.1 m/s^2 (to 2 fig.)

8.5 Resultant force acting on whole system is the difference between the weights of the two masses, i.e, the weight of a 1.0 kg mass

But weight = mass x g

:. Force = 1.0 x 9.8

And mass being accelerated = 3.0 + 2.0

As acceleration $= \frac{\text{force}}{\text{mass}}$

$= \frac{1.0 \times 9.8}{5.0}$

= 1.96

= 2.0 m/s^2 (to 2 fig.)

8.7 As acceleration $= \frac{\text{force}}{\text{mass}} = \frac{5}{0.1}$

= 50 m/s^2

8.9 The lift must exert a force to equal the weight of the man plus the force to accelerate him upwards.

As force = mass x acceleration

= 100 x 9.8 + 100 x 2.0

= 1 180 N

= 1200 N (to 2 fig.)

8.10 The normal reaction between the horizontal surfaces equals the weight of the block, 20 N

Mass to be accelerated $= \frac{\text{totalweight}}{g} = \frac{40+10}{9.8}$

As acceleration $= \frac{\text{force}}{\text{mass}}$

$= \frac{10 \times 9.8}{50}$

= 1.96

= 2.0 m/s^2 (to 2 fig.)

(b) Frictional force = normal reaction x Coefficient of friction

= 40 x 0.10

= 4.0 N

:. Accelerating force = 10.0 – 4.0 = 6.0 N

:. Acceleration $= \frac{6.0 \times 9.8}{50}$

= 1.176 = 1.2 m/s^2 (to 2 fig.)

9.1 Gain in potential energy

= mass x g x gain in height

= 20 x 9.8 x 10

= 1960 = 2000 J (to 2 fig)

9.3 As kinetic energy = $\frac{1}{2}$ x mass x velocity2

= $\frac{1}{2}$ x 900 x 302

= 405 000 J = 405 kJ

9.5 Work done = weight x height

= mass x g x height

= 200 x 9.8 x 30 J

Power $= \frac{\text{work done}}{\text{time taken}}$

$= \frac{200 \times 9.8 \times 30}{24.5}$

= 2400 W

= 2.4 kW

9.7 Energy supplied to pump per minute

= power x time

= 2000 x 60

= 120000 J

Useful work done per minute

= weight raised per minute x height

= mass per minute x g x height

= 600 x 9.8 x 15 = 88 200 J

:. Energy lost per minute

= energy supplied per minute

Useful work done per minute

= 120000 – 88200

= 31800

= 32000 J (to 2 fig.) = 32 kJ

9.8 Extra work done per minute

= weight lifted per minute x height

= mass lifted per minute x g x height

= 20 x 75 x 9.8 x 8.0

And extra work done per second

= power needed

$$= \frac{20 \times 75 \times 9.8 \times 8.0}{60}$$

= 1960 W = 2.0 kW (to 2 fig.)

9.11 In one second car travels 25 m along the ground and if it climbs a hill of 1 (up) in 20 (along slops), it rises $\frac{25}{20}$ m.

:. Extra work done per second $= 800 \times 9.8 \times \frac{25}{20}$

= 9800 W

= 9.8 kW

9.15 Initial potential energy = mass x g x height

= mass x 9.8 x 20

This becomes kinetic energy, 10% is lost on impact and then becomes all potential energy as the ball reaches its maximum rebound height (h)

:. Final potential energy $= \frac{90}{100} \times \text{mass} \times 9.8 \times 20$

= mass x 9.8 x h

:. $h = \frac{90 \times 20}{100} = 18$ m

10.1 Let velocity of recoil of gun be v

Then momentum of bullet = mass x velocity

= 0.010 x 60

And momentum of gun = 40 x v in opposite direction

And by the conservation of momentum,

0010 x 60 = 4.0 x v

= 0.15 m/s

10.3 Let initial speed of trolley be v Then momentum of man

= mass x velocity

= 80 x 4.0

And momentum of trolley = 320 x v

And by the conservation of momentum

80 x 4.0 = 320 x v

:. **v = <u>1.0 m/s</u>**

10.4 Let the velocity after impact be v momentum of first truck = mass x 18 = 8000 x 18

And momentum of three trucks = 3 x 8000 x 18

By the conservation of momentum salami trout

8000 x 18 = 3 x 8000 x v

:. V = 6.0 m/s

Kinetic energy of first truck before impact = $\frac{1}{2}$ x mass x velocity ^{2}

= $\frac{1}{2}$ x 8000 x 18^2

= $\frac{1}{2}$ x 8000 x 324

= 162 x 8000

Kinetic energy of three trucks after impact

= $\frac{1}{2}$ x 3 x 8000 x 62

= 54 x 8000

:. Loss of energy = 162 x 8000 – 54 x 8000

= 108 x 8000

= 864000

= <u>860 kJ (to 2 fig.)</u>

11.1 Increased in length = expansivity x original length x change in temperature

= 0.000012 x 1.000 x 100

= 0.0012 m

:. Length at 100^0C = 1.001 [2] m

11.2 Let final temperature be 0 (in ^{0}C) Increase in length = linear expansivity x original length x change in temperature

:. (1.0085 – 1.000) = 0.000017 x 1.000 x (θ – 10)

:. 0.0085 = 0.000017 × (θ – 10

:. θ – 10 = 500

:. **<u>θ = 510^0C</u>**

11.5 Increase in length = liner expansively x original length x change in temperature so at 100^0C side increase by = 0.000010 x 0.1000 x 100

= 0.000 10 m

= 0.1 mm

So length of side at 100^0C. = 100.1 mm

= 0.100 1mm

:. Volume of cube = (length of side)^3

= $(0.100\ 1)^3$

= 0.001 003 m^3

:. Density of steel = $\frac{\text{mass}}{\text{volume}}$

= $\frac{7.800}{0.001003}$

= 7776.6

= **<u>777 kg/m³ (to 4 fig)</u>**

11.6 An increase in length = linear expansively x original length x change in temperature let temperature required be θ (in ^{0}C) For brass increase in length

For steel increase in length = 0.000018 x 1.0000 x (θ - 0)

For steel increase in length = 0.000010 x 1.001 x (θ - 0)

:. Final length of brass = 1.0000 + 0.00018 x 1.0010 x θ

And these must be the same

1.0000 + 0 + 0.000018 x θ = 1.0010 + 0.000010010 x θ

:. 0.0010 = 0.0010

= 0.00000799 x θ

θ = $\frac{1.0}{0.00799}$

θ = <u>125.2^{0}C</u>

11.9 Let the length of the copper rod be ℓ if the rods have a constant difference in length, then the increase in length for any temperature change, e.g. K, is the same for both.

As increase in length = linear expansivity x original length x change in temperature

For brass increase in length 0.000018 x 1.000 x 1

For copper increase in length = 0.000017 x ℓ x 1

:. 0.000018 x 1.000 x 1 = 0.000017 x ℓ x 1

:. 17ℓ = 18

:. ℓ = $\frac{18}{17}$ = 1.058 8

<u>= 1.059 m (to 4 fig)</u>

11.11 The diameter of the hole increases in the same way as the diameter of the piece of steel which originally filled it.

As increase in length = linear expansivity x original length x change in temperature = 0.000 010 x 0.003 000 x 300

= 0.000 009 0 m

= 0.0009 0 mm

<u>So new diameter is 3.009 mm</u>

12.1 As the scale of the thermometer is to be taken as linear Taken as linear

100 degrees occupy 213 – 63 = 150 mm so 108 – 63 = 45 mm

correspond to $\frac{100 \times 45}{150}$ = 30 degrees

And this is from the 0^0C mark,

:. Liquid temperature = 30^0C.

12.2 As the scale of the thermometer is to be taken as linear 3.5 mV corresponds to 100 degrees.

:. 6.3 mV corresponds to $\frac{100 \times 6.3}{3.5}$ = 180 degrees

And this from 0^0C .

13.1 Let the final temperature be θ (in 0C)

Use heat energy change = mass x specific heat capacity x change in temperature

Heat energy lost by hot water = 6.0 x 4200 x (700 - θ)

Heart energy gained by cold water = 4.0 x 4200 x (θ - 10)

And as heat energy lost = heat energy gained

6.0 x 4200 x (70 - θ) = 4.0 x 4200 x (θ - 10)

:. 6.0 (70 - θ) = 4.0 (θ - 10)

:. 420 – 6.0 θ = 4.0 θ - 40

:. 10θ = 460

:. **θ = 46⁰C**

13.2 Let the final temperature be θ (in 0C) Use heat energy change = mass x specific heat capacity x change in temperature.

Heat energy lost by hot copper = 10.0 x 380 x (100 -θ)

Heat energy gained by hot copper = 10.0 x 380 x (100 - θ)

Heat energy gained by cold water = 7.6 x 4200 x (θ - 30)

And as heat energy lost = heat energy gained

:. 10.0 x 380 x (100 - θ) = 7.6 x 4200 x (θ - 30)

:. 5 (100 - θ) = 42 (θ - 30) (dividing by 760)

:. 500 - 5θ = 42θ - 1260

47θ = 1760

θ = 37.4

= 37^0C(to 2 fig.)

13.5 Let the final temperature be θ (in 0C)

Use heat energy change = mass x specific heat capacity x change in temperature.

Heat energy lost by hot iron = 3.0 x 460 x (100 - θ)

Heat energy gained by cold water = 4.6 x 4200 x (θ - 20)

= 2.0 x 460 x (θ - 20)

:. And heat energy lost = total heat energy gained

:. 3.0 x 460 x (100 - θ) = 4.6 x 4200 x (θ - 20) + 2.0 x 460 x (θ - 20)

3.0 (100 - θ) = 42 (θ - 20) + 2.0 (θ - 20)

(dividing by 4600)

:. $300 - 3.0\theta = 42\theta - 840 + 2.0\,\theta - 40$

: $47\theta = 1180$

:. $\theta = 25.1$

$= \underline{\mathbf{25^0C}}$ **(to 2 fig.)**

Heart energy gained by copper calorimeter = 0.100 x 380 x (θ - 20)

And heat energy lost = total heat energy gained

:. 0.020 x 380 x (100 - θ) = 0.190 x 4200 x (θ - 20) + 0.100 x 380 x (θ - 20)

:. 2 (100 - θ) = 210 (θ - 20) + 10 (θ - 20)

(dividing by 3.8)

:. 200 - 2θ = 210 θ - 4200 + 10 θ - 200

:. 222 θ = 4 600

:. θ = 20.7

$= \underline{\mathbf{21^0C}}$ **(to 2 fig.)**

13.9 Let the specific heat capacity of the metal be c

Use heart energy change = mass x specific heat capacity x change in temperature

Heat energy lost by hot metal = 0.030 x c x (90.0 – 22.1)

Heat energy gained by metal calorimeter = 0.070 x c x (22.1 – 20)

And heat energy lost = total heat energy gained

:. 0.030 x c x 67.9 = 0.090 x 4200 x 2.1 + 0.070 x c x 2.1

:. 3 x c x 97 = 9.0 x 4200 x 3 + c x 21

(dividing by 0.007)

:. 97c = 9.0 x 4200 + 7c (dividing by 3)

:. 90c = 9.0 x 4200

:. **c = 420 J/kg K**

13.11 Let the original temperature of the nail be θ (in ^{0}C)

Use heat energy change = mass x specific heat capacity x change in temperature

Heat energy lost by hot nail = 0.004 x 460 x (θ - 22)

Heat energy gained by cold water = 0.115 x 4200 x (22.0 – 20.0)

Heat energy gained by iron calorimeter = 0.090 x 460 x (22.0 – 20.0)

And heat energy lost = total heat energy gained

:. 0.004 x 460 x (θ - 22) = 0.115 x 4200 x 2.0 + 0.090 x 460 x 2.0

:. 4(θ - 22) = 2100 + 90 x 2.0

(dividing by 0.460)

:. 4θ - 88 = 2100 + 180

:. 4θ = 2368

θ = 592

$= \underline{\mathbf{592^0C}}$ **(to 2 fig.)**

13.13 Total heat energy supplied = mass x specific heat capacity x rise in temperature = 4.0 x 2500 x (56 – 20)

= 360 000 J

Time taken = 10 min.

= 600 s.

:. Power = $\dfrac{\text{energy}}{\text{time}}$

= $\dfrac{360000}{600}$

= 600 W

13.15 Total heat energy supplied to water = mass x specific heat capacity x rise in temperature = 2.4 x 4200 x (70 – 20)

As this takes 10 min = 600 s

Heat supplied per second = $\dfrac{2.4 \text{ x } 4200 \text{ x } 50}{600}$

And heat energy needed by glycerine

= 2.1 x 2400 x 25

Time taken = $\dfrac{\text{heat energy needed}}{\text{energy supplied per second}}$

= $\dfrac{2.1 \text{ x } 2400 \text{ x } 25 \text{ x } 600}{2.4 \text{ x } 4200 \text{ x } 4 \text{ x } 50}$

= 150 s

= 2.5 min.

13.17 As heat energy needed = mass x specific heat capacity x rise in temperature

Heat energy needed to heat water = 3.0 x 4200 x (100 – 20)

Heat energy needed to heat kettle = 3.5 x 380 x (100 – 20)

:. Total energy needed = 3.0 x 4200 x 80 + 3.5 x 380 x 80

But energy is supplied at s rate of 2.8 kW = 2800 W

:. Time needed = $\dfrac{\text{total energy}}{\text{rate of supply}}$

= $\dfrac{3.0 \text{ x } 4200 \text{ x } 80 + 3.5 \text{ x } 380 \text{ x } 80}{2800}$

= 398 s

= 6.6 min.

13.18 As heater power =

$$\frac{\text{heat energy supplied per second.mass x specific heat capacity x rise in temperatur}}{\text{time taken}}$$

For heater A

Power $= \dfrac{4.0 \text{ x } 880 \text{ x } (32 - 21)}{550}$

$= 70.4$ W

For heater B

Power $= \dfrac{10.0 \text{ x } 380 \text{ x } (39 - 23)}{950} = 64$ W

So heater A is the more powerful.

13.21 Let specific heat capacity of the metal be c

As heater power = heat energy supplied per second

Mass x specific heat capacity = $\dfrac{\text{x rise in temperature}}{\text{time taken}}$

:. 100 $= \dfrac{4.0 \text{ x } c \text{ x } (57 - 15)}{14 \text{ x } 60}$

:. c $= \dfrac{100 \text{ x } 14 \text{ x } 60}{4 \text{ x } 42}$

= **<u>500 J/kg K</u>**

14.1 (a) To raise the temperature of the ice from – 20^0C to 0^0C

Heat energy needed = mass x specific heat capacity x Rise in temperature

= 2.0 x 2 100 x 20

= 84 000 J

To melt the ice at 0^0C

Heat energy needed = mass x specific latent heat

= 2.0 x 340 000

= 680 000 J

So total energy = 84 000 + 680 000

= 76400J

= **<u>760 kJ (to 2 fig.)</u>**

(b) In addition to (a)

To raise the temperature of the water formed to 300C

Heat energy needed = mass x specific heat capacity x rise in temperature = 2.0 x 4200 x 30

= 252000 J

So total energy = 76400 + 252000

= 1016000 J

= **<u>1.0 MJ (to 2 fig)</u>**

(c) In addition to (a)

To raise the temperature of the water formed to 100^0C

Heat energy needed = mass x specific heat capacity x rise in temperature = 2.0 x 4200 x 100

= 840000 J

To turn the water at 100^0C to steam at 100^0C

Heat energy needed = mass x specific latent heat

= 2.0 x 2250 000

= 4500000 J

So total energy = 764000 + 840 000 + 4500 000

= 6104 000J

= **<u>6.1 MJ (to 2 fig)</u>**

14.3 Let the final temperature be θ (in 0c) Heat energy gained by ice in melting = mass x specific latent heat = 2.1 x 340 000

Heat energy gained by water formed in warming to final temperature = mass x specific heat capacity x rise in temperature

= 2.1 x 4200 x (θ - 0)

Heat energy lost by warm water = mass x specific heat capacity x fail in temperature = 5.9 x 4200 x (40 - θ)

:. 340 + 4.2θ = 11.8 (40 - θ) (dividing by 2100)

:. 340 + 4.2θ = 472 – 11.8 θ

16θ = 132

θ = 8.25^0C

= **<u>8.3^0 (to 2 fig.)</u>**

14.5 Let the final temperature be θ (in ^{0}C) Heat energy gained by ice in melting = mass x specific heat capacity x change in temperature.

Heat energy gained water formed from ice= 1.05 x 340000

For the rest, heat energy change = mass x specific heat capacity x change in temperature.

Heat energy gained by water formed from ice = 1.05 x 4200 x (θ - 0)

Heat energy lost by hot water = 1.62 x 4200 x (70 - θ)

= 1.620 x 380 x (70 - θ)

Heat energy lost by copper calorimeter = 4.20 x 380 x (70 - θ)

And total heat energy gained = total heat energy lost

:. 1.05 x 340 000 + 1.05 x 4200 x θ = 1.62 x 4200 x (70 - θ)

$+ 4.20 \times 380 \times (70 - \theta)$

:. $34\,000 + 420\theta$ = $162\ (70 - \theta)$ (diving by 10.5)

X $(70 - \theta)$ (dividing by 10.5)

:. $8500 + 105\ \theta$ = $162\ (70 - \theta) + 38\ (70 - \theta)$

(dividing by 4)

= $200\ (70 - \theta)$

:. $8500 + 105\ \theta$ = $14000 - 200\ \theta$

:. $305\ \theta$ = 5500

= 18.03

= **<u>18^0C (to 2 fig.)</u>**

Let the final temperature be θ (in ^{0}C)

Heart energy lost by steam in condensing at 100^0C = mass x specific latent heat

= 0.21×2250000

For the rest, heat energy change = mass x specific heat capacity x change in temperature

Heat energy lost by water formed from steam in cooling

= $0.21 \times 4200 \times (100 - \theta)$

Heat energy gained by cold water = $2.0 \times 4200 \times (\theta - 10)$

Heat energy gained by iron calorimeter = $0.42 \times 460 \times (\theta - 10)$

And total heat energy gained

:. $0.21 \times 2250000 + 0.21 \times 4200 \times (100 - \theta) = 2 \times 4200 \times (\theta - 10) + 0.42 \times 460 \times (\theta - 10)$

:. $112500 + 210\ (100 - \theta)$ = $2000\ (\theta - 10) + 46\ (\theta - 10)$

(dividing by 4.2)

:. $112500 + 21000 - 210\theta$ = $2000\theta - 20000 + 46\ \theta - 460$

:. $2256\ \theta$ = 153960

:. θ = 68.2

= **<u>68^0C (to 2 fig.)</u>**

14.9 Let the mass of ice needed be m Heat energy lost by steam in condensing = mass x specific latent heat

= 0.34×2250000

Heat energy lost by water formed in cooling = mass x specific heat capacity x fall in temperature = $0.34 \times 4200 \times (100 - 34)$

Heat energy gained by ice in melting = mass x specific heat latent heat = $m \times 340000$

Heat energy gained by water formed in warming = mass x specific heat capacity x rise in temperature = $m \times 4200 \times (34 - 0)$

And total heat energy lost = total heat energy gained

:. $0.34 \times 2250000 + 0.34 \times 4200 \times 66 = m \times 340000 + m \times 4200 \times 34$:. $22500 + 42 \times 66 = m \times 10000 + m \times 4200$

(dividing by 34)

:. 22500 + 2772 = 14200m = 25272

:. **M = 1.78 = 1.8 kg (to 2 fig.)**

(N.B. the original water and the container do not come into the calculation as their initial and final temperatures are the same.)

14.11

Let mass of ice formed = m

Heat energy gained by aluminum = mass x specific heat capacity x rise in temperature. = 0.68 x 880 x 120

Heat energy lost water = mass x specific latent heat

= m x 340000

And heat energy gained = heat energy lost

:. 0.68 x 880 x 120 = m x 340000

:. 88 x 12 = 5000 m (diving by 68)

:. 11 x 12 = 625 m (diving by 8)

:. 625 m = 132

:. M = 0.211

= **0.21 kg (to 2 fig)**

14.13 Heat energy to be removed from water in cooling = mass x specific heat capacity x fall in temperature = 0.80 x 4200 x 10

Heat energy to be removed from water in freezing = mass x specific latent heat = 0.80 x 34000

$$\text{And time taken} = \frac{\text{total heat energy to be removed}}{\text{rate of removal of energy}}$$

$$= \frac{0.80 \times 4200 \times 10 + 0.80 \times 340000}{50}$$

= 6112 s

= **100 min. (to 2 fig.)**

14.15 et the initial temperature of the copper be θ (in ^{0}C)

Heat energy lost by copper = mass x specific heat capacity x fail in temperature = 1.7 x 380 x ((θ - 0)

Heat energy gained by ice = mass x specific latent heat

= 0.38 x 340000

And heat energy lost = heat energy gained

:. 1.7 x 380 x θ = 0.38 x 340000

:. 38 x θ = 0.38 x 20000

(dividing by 17)

:. θ = 200^{0}C (dividing by 38)

14.17 Let the specific latent heat of the metal be ℓ

Heat energy lost by metal in solidifying = mass x specific latent hea

= 0.20 x ℓ

Heat energy lost by solid metal in cooling = mass x specific heat capacity x fall in temperature = 0.20 x 400 x (500 – 400)

Heat energy gained by water = mass x specific heat capacity x rise in temperature = 2.0 x 4200 x (40 – 20)

And as total heat energy lost = heat energy gained

:. 0.20 x ℓ + 0.20 x 400 x 460 = 2.0 x 4200 x 20

:. ℓ + 400 x 460 = 10 x 4200 x 20

(dividing by 0.20)

:. ℓ + 184000 = 840000

ℓ = 656000 J/kg

= **660000 J/kg (to 2 fig.)**

14.19 Let mass of ice melted per minute = m Heat energy supplied per minute = power x time = 3400 x 60

= mass melted per minute x specific latent heat

= m x 340 000

:. 3400 x 60 = m x 340 000

:. M = 0.60 kg

14.21 Let the mass of ice = m Then heat energy needed to melt ice

= mass x specific latent heat

= m x 340000

And this is supplied in 34 min = 34 x 60s

:. Heat energy supplied per second = $\dfrac{\text{total heat energy}}{\text{time taken}}$

$= \dfrac{m \times 340000}{34 \times 60}$

(a) To raise the temperature from 0^0C to 100^0C

Heat energy needed = mass x specific heat capacity x change in temperature = m x 4200 x 100

:. Time taken = $\dfrac{\text{total heat energy needed}}{\text{heat energy supplied per second}}$

$= \dfrac{m \times 4200 \times 100 \times 34 \times 60}{m \times 340000}$

= 42 x 60 s

= **42 min.**

(b) To boil half the water away Heat energy needed = mass x specific latent heat = $\frac{1}{2}$ x m x 2250 000

:. Time taken = $\dfrac{\text{heat energy needed}}{\text{heat energy supplied per second}}$

= $\dfrac{m \times 2250000 \times 34 \times 60}{2 \times m \times 340000}$

= 112.5 x 60 s

= 112.5 min

= **<u>110 min. (to 2 fig.)</u>**

14.23 (a) Use heat energy change = mass x specific heat capacity x change in temperature Heat energy to be removed from water = 0.2 x 4200 x 20

Heat energy to be removed from tray = 0.1 x 880 x 20

:. Total heat energy to be removed = 0.2 x 4200 x 20 + 0.1 x 880 x 20

:. Time taken = $\dfrac{\text{total energy}}{\text{power}}$

= $\dfrac{0.2 \times 4200 \times 20 + 0.1 \times 880 \times 20}{100}$

= 4 x 42 + 8.8 x 2

= 168 + 17.6

= 185.6 s

<u>= 3.1 min. (to 2 fig.)</u>

(c) The tray does not change so plays no part.

Heat energy to be removed to turn water to ice = mass x specific latent heat = 0.2 x 340 000

:. Time taken = $\dfrac{\text{total energy}}{\text{power}}$

= $\dfrac{0.2 \times 3400000}{100}$

= 680 s = 11.3 min.

<u>= 11 min (to 2 fig.)</u>

15.1 Let second volume be V_2 (a) By Boyle's law, pressure1 x volume$_1$

= Pressure$_2$ volume$_2$

:. 100000 x 0.0020 = 400000 x V_2

: $V_2 = \frac{0.0020}{4}$

$= 0.0005m^3$

(b) Let second pressure be P_2

By Boyle's law, pressure$_1$ x volume$_1$

= pressure$_2$ x volumes$_2$

:; 100000 x 0.0020 = p_2 x 0.0040

:. $P_2 = \frac{100\,000}{2} = 50\,000\ N/m^2$

15.2 It is most convenient to work problem with pressures measured in mm Hg and volumes measured as mm of air column. This is possible in this case because the same units are used on both sides of each equation. This is only possible in a few cases.

With the tube horizontial internal air pressure = atmospheric pressure = 750 mmHg

Volume of air = 56 mmHg of tube (a) Internal air pressure

= atmospheric pressure + pressure due to mercury thread

= 750 + 50 = 800 mmHg

= pressure$_2$ x volume$_2$

:. 750 x 56 = 800 x V_2

:. $V_2 = \frac{750x56}{800}$

= 52.5

= **<u>53 mm of tube (to 2 fig.)</u>**

(b) Internal air pressure = atmospheric pressure – pressure due to mercury thread = 750 - 50

= 700

Let volume be V_3

Then by Boyle's law, pressure$_1$ x volume$_1$

= pressure$_3$ x volume$_3$

:. 750 x 56 = 700 x V_3

:. $V_3 = \frac{750x56}{700}$

$= \frac{75x8}{10}$

= **<u>60 mm of tube</u>**

15.5 Pressure due to water

= depth x density x g

= 20 x 1000 x 9.8

= 196000 N/m_2

:. Total pressure at bottom of water

= atmospheric pressure + water pressure

= 98000 + 196000

= 294 000 N/m_2

Let volume just below surface, where pressure is atmospheric = V_2 By Boyle's law, $pressure_1$ x $volume_1$

= pressure2 x volume2

294000 x 0.000003

= 98 000 x V^2

:. V_2 = 3 x 0.000 003 (dividing by 98 000)

= **0.000 009 m^3**

15.6 let pressure at bottom of sea be p_2 and volume of bell be V. by Boyle's law, pressure1 x volume2 = pressure2 x volume2

$$:.\quad 98000 \times V = p_2 \times \frac{2V}{3}$$

$$:.\quad P_2 = \frac{3 \times 98000}{2}$$ but this is due to atmospheric pressure + water pressure

:. Water pressure = P_2 – atmospheric pressure

$$= \frac{3 \times 98000}{2} - 98000$$

$$= \frac{98000}{2}$$

But also = depth x density x g

= depth x 1025 x 9.8

$$:\quad \text{Depth} = \frac{98000}{2 \times 1025 \times 9.8}$$

$$= \frac{5000}{1025}$$

= 4.88

= **4.9 m (to 2 fig.)**

15.9 when cylinder is opened the pressure falls to atmospheric, so by Boyle's law the volume becomes ten times the volume of the cylinder. Thus, only one tenth of the gas ca remain in the cylinder.

Thus, mass escaping = $\frac{9}{10}$ x 50
= 4.5 kg.

15.11 [See first paragraph of solution to 15.3]
First volume = 126 mm of tube
First pressure = 750 mmHg
Second volume = 84 mm of tube
Second pressure = P_2
By Boyle's law, pressure$_1$ x volume$_1$
= pressure$_2$ x volume$_2$
:. 750 x 126 = P_2 x 84
:. P_2 = 750 x 1.5 (dividing by 84)
But this is due to atmospheric pressure + mercury pressure
:. Mercury pressure = Total pressure – atmospheric pressure
= 750 x 1.5 – 750
= 750 x 0.5
= 375 mmHg
:. Difference between mercury levels = 375 mm

15.11 [See first paragraph of solution to 15.3]
First volume = 126 mm of tube
First pressure = 750 mmHg
Second volume = 84 mm of tube
Second pressure = P_2
By Boyle's law, pressure$_1$ x volume$_1$
= pressure$_2$ x volume$_2$
:. 750 x 126 = P_2 x 84
:. P_2 = 750 x 1.5 (dividing by 84)
But this is due to atmospheric pressure + mercury pressure
:. Mercury pressure = Total pressure – atmospheric pressure
= 750 x 1.5 – 750
= 750 x 0.5
= 375 mmHg
:. Difference between mercury levels = 375 mm

15.13 [see first paragraph of solution to 15.3] In the fist case the pressure of the air above the mercury = true atmospheric pressure – faulty barometer reading = 750 – 740 = 10 mmHg. The volume of this air is 32 mm of tube, which makes the top of the tube at the 772 mm "mark".
In the second case the volume of the air is 772 – 732 = 40 mm of the tube. Let the pressure be p_2
Then by Boyle's law,
pressure$_1$ x volume$_1$ = Pressure$_2$ x volume$_2$

:. $10 \times 32 = p_2 \times 40$

:. $P_2 = \frac{10 \times 32}{40}$

$= 8$ mmHg

:. True atmospheric pressure – faulty barometer reading

$= P_2$

:. True atmospheric pressure – 732

$= 8$

:. **True atmospheric pressure = 740 mmHg**

15. 15 (a) The air in the vessel fills the pump and vessel after one stroke

Let the pressure become p_1

By Boyle's law, $\text{pressure}_0 \times \text{volume}_0$

$= \text{pressure}_1 \times \text{volume}_1$

:. $100\,000 \times 0.0090 = p_1 \times 0.0100$

:. $P_1 = 90\,000$ N/m_2

b(During the second stroke the pressure first remains constant while the air in the pump is swept out, so the volume of air returns to 0.0009 0 m3 at a pressure of 90 000 N/m^2. It then expands as before to a pressure p_2, so as before $90\,000 \times 0.009\,0 = p_2 \times 0.0100$

:. $P_2 = 81\,000$ N/m^2 and for a third stroke $81\,000 \times 0.009\,0 = 72\,900$ N/m^2

:. $P_3 = 73\,000$ N/m^2 (to 2 fig.)

1 The first absolute temperature = Celsius temperature + 273

$= 27 + 273$

$= 300$ k

The second absolute temperature $= 127 + 273 = 400$ K

(a) let final pressure be p_2 As volume is constant, apply law of pressure

$$\frac{\text{pressure}_1}{\text{absolute temperature}_1} =$$

$$:. \frac{0.12}{300} = \frac{V_2}{400}$$

$$:. V_2 = \frac{0.12 \times 400}{300}$$

$$= 0.16\text{m3}$$

Let initial volume be V, the initial pressure be p and the final volume be V_2 .

Apply the ideal gas equation

$$\frac{\text{pressure}_1 \times \text{volume}_1}{\text{absolute temperature}_1} = \frac{\text{pressure}_2 \times \text{volume}_2}{\text{absolute temperature}_2}$$

$$:. \quad \frac{p \times V}{27+273} = \frac{3p \times V2}{327+273}$$

$$:. \quad V_2 = \frac{p \times V \times (327+273)}{3p \times (27+273)}$$

$$= \frac{p \times V \times 600}{3p \times 300}$$

$$= \frac{2V}{3}$$

:. Volume is reduced to two thirds of the original volume.

16.5 As pressure in s.t.p is given in mmHg. This unit may be used as it occurs on both sides of the equation. This procedure only works in a few cases.
Let final volume be V_2
Then by the ideal gas equation

$$\frac{\text{Pressure}_1 \times \text{volume}_1}{\text{absolute temperature1}} = \frac{570 \times 0.125}{102+273}$$

$$= \frac{760 \times V_2}{0+273}$$

$$= \frac{570 \times 0.125 \times 273}{760 \times 375}$$

$$= \frac{3 \times 0.125 \times 273}{4 \times 375}$$

(canceling by 190)

$$= \frac{0.273}{4}$$

(canceling by 375)

$= 0.0683m^3$ (to 3 fig.)

16.7 [ee first paragraph of solution to 16.5]
Consider a volume of 1 m^3 of chlorine at s.t.p

As mass = volume x density
= 1 x 3.2
= 3.2 kg

Let second volume of the chlorine be V_2 Apply the ideal gas equation (assuming that chlorine acts as an ideal gas).

$$\frac{\text{Pressure}_1 \text{ x volume}_1}{\text{absolute temperature}_1} = \frac{\text{Pressure}_2 \text{ x volume}_2}{\text{absolute temperature}_2}$$

$$\frac{760 \text{x} 1}{0+273} = \frac{950 \text{x} V_2}{91+273}$$

$$\therefore V_2 = \frac{760 \text{ x} 1 \text{x} 364}{950 \text{x} 273}$$

$$= \frac{4 \text{ x} 364}{5 \text{x} 273}$$

(canceling by 190)

$$= \frac{4 \text{ x} 4}{5 \text{x} 3}$$

(canceling by 91)

$$\frac{16}{15}$$

So new density $= \dfrac{\text{mass}}{\text{new volume}}$

$$= \frac{3.2 \text{x} 15}{16}$$

$$\underline{= \quad \mathbf{3.0\ kg/m^3}}$$

16.9.. Let required temperature be T_2 (in K)
Use law of pressures (ignoring the expansion of the bottle)

$$\frac{\text{Pressure}_1}{\text{absolute temperature}_1} = \frac{\text{Pressure}_2}{\text{absolute temperature}_2}$$

$$\therefore \frac{90000}{27+273} = \frac{225000}{T_2}$$

$$\therefore T_2 = \frac{225000 \text{x} 300}{90000}$$

$$= \frac{225\,000}{300}$$

(canceling by 300)

$$= 750 \text{ K}$$

$$= 477^0\text{C}$$

$$\underline{= \mathbf{480^0C\ (to\ 2\ fig.)}}$$

16.11 [See first paragraph of solution to 16.5]

The excess pressure is assumed to vary uniformly with temperature.

So a change of 100K corresponds to a pressure change of

138 – (- 12) = 150 mmHg

So a pressure change of 33 – (- 12) = 45 mmHg

Corresponds to $\frac{100 \text{x} 45}{150}$ = 30 K change

This is a change from 0^0 C.

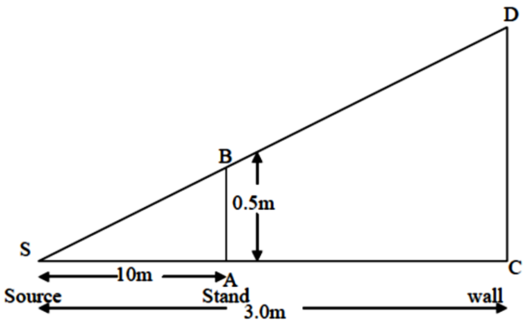
:. Temperature measured is 30^0C.

17.1 As $\frac{\text{height of house}}{\text{lenght of image}} = \frac{\text{distance away of house}}{\text{lenght of image}}$

:. $\frac{10}{\text{lenght of image}} = \frac{30}{0.150}$

:. Length of image $\frac{10 \text{x} 0.150}{30}$ = 0.050 m

= 50 mm



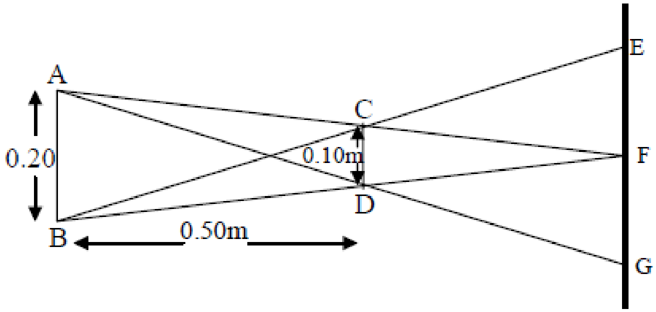
17.3

As triangles SAB and SCD are similar

$$\frac{CD}{AB} = \frac{CS}{AS}$$

$$\frac{CD}{0.5} = \frac{3.0}{1.0}$$

:. $CD = 1.5$ m



The umbra region is CFD, so the screen must be placed at EFG.
As triangles AFB and CFD are similar.

$$\frac{\text{height of CFD}}{\text{height of AFB}} = \frac{CD}{AB}$$

$$= \frac{0.1}{0.2}$$

So $$\frac{\text{height of CFD}}{\text{height of CFD} + 0.50} = \frac{1}{2}$$

:. Height of Δ CFD $=$ 1.0 m

:. Screen is 1.0 m from source.

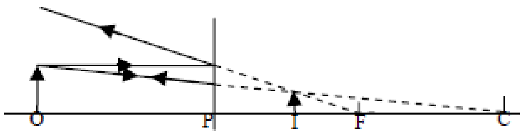


Fig 19

18.1 (a)

(i) Draw principal axis:
(ii) Draw line to represent mirror at P;
(iii) Mark F and C on a suitable horizontal scale;
(iv) Mark object position and height;
(v) Draw ray from tip of object parallel to axis reflected as though it had come from F and produce back;
(vi) Draw ray from tip of object to-wards C, reflected along its own path and produce back;
(vii) where (v) and (vi) cross, draw in image;

(viii) The image is found to be 0.086 m behind the mirror, 43 mm high, erect and virtual.

Or Let v = image distance

As $\frac{1}{\text{object distance}} + \frac{1}{\text{image distance}} = \frac{1}{\text{focal length}}$

$$\frac{1}{0.20} + \frac{1}{v} = -\frac{1}{0.15}$$

(- for a convex mirror)

$$\therefore \frac{1}{v} = -\frac{1}{0.15} - \frac{1}{0.20}$$

$$= \frac{-4-3}{0.60}$$

$$= \frac{-7}{0.60}$$

$$= -\frac{0.60}{7} = -0.086 \text{ m}$$

And $\frac{\text{size of image}}{\text{size of object}} = \frac{\text{image distance}}{\text{object distance}}$

$$\therefore \frac{\text{size of image}}{0.010} = \frac{086}{20}$$

<u>:. Size of image = 0.004 3 m</u>

So image is 0.086 m, behind the mirror, 4.3 mm high, erect and virtual.

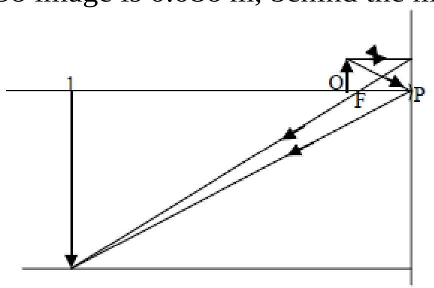


Fig. 20

(b)

(i) Draw principal axis:

(ii) Draw line to represent mirror at P;

(iii) Mark F and C on a suitable horizontal scale;

(iv) Mark object position and height;

(v) Draw ray from tip of object parallel to axis reflected as though it had come from F and produce back;
(vi) Draw ray from tip of object through C , reflected back along its own path
(vii) where (v) and (vi) cross, draw an image;
(viii) The image is found to be 0.60 m infront of the mirror, 30 mm high, inverted and real.
Or Let v = image distance

As $\frac{1}{\text{object distance}} + \frac{1}{\text{image distance}} = \frac{1}{\text{focal length}}$

$$\frac{1}{0.20} + \frac{1}{v} = +\frac{1}{0.15}$$

(+ for a concave mirror)

$$\therefore \frac{1}{v} = \frac{1}{0.15} - \frac{1}{0.20}$$

$$= \frac{4-3}{0.60}$$

$$= \frac{1}{0.60}$$

$$v = 0.60 \text{ m}$$

And $\frac{\text{size of image}}{\text{size of object}} = \frac{\text{image distance}}{\text{object distance}}$

$$\therefore \frac{\text{size of image}}{0.010} = \frac{0.60}{0.20}$$

$\therefore$ Size of image = 0.030m

So image is 0.60m in front of the mirror,
30mm high, inverted and real.

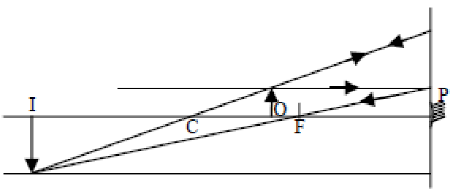


Fig 21

18.3(a)
(i) Draw principal axis;
(ii) Draw line to represent mirror at P

(iii) Mark F and C on a suitable horizontal scale;
(iv) Draw a line parallel to, and above the axis so that the tip of the image is on the line.
(v) Draw a line parallel to, and below the axis so that the tip of the image is on the line. It must be below and in front of the mirror because the image is real. It must be because the image is real. It must be three times the distance of (iv) from the axis so that the image is magnified three times;
(vi) Draw the ray from the tip of the object parallel to the axis (i.e. along (iv)), reflected through F;
(vii) Where (vi) crosses (v) is the tip of the image;
(viii) Draw the ray through the tip of the image and through which reflects back along its own path from the mirror;
(ix) Where (viii) crosses (iv) is the tip of the object;
(x) The object is 0.24 m from the mirror

Or As magnification $= \dfrac{\text{image distance}}{\text{object distance}}$

$$3 = \frac{\text{image distance}}{\text{object distance}}$$

:. Image distance = 3 x object distance

But $\dfrac{1}{\text{object distance}} + \dfrac{1}{\text{image distance}} = \dfrac{1}{\text{focal length}}$

Let object distance = u

$$:.\quad \frac{1}{u} + \frac{1}{3u} = \frac{1}{0.18}$$

$$:.\quad \frac{4}{3u} = \frac{1}{0.18}$$

:. **u = 0.24 m**

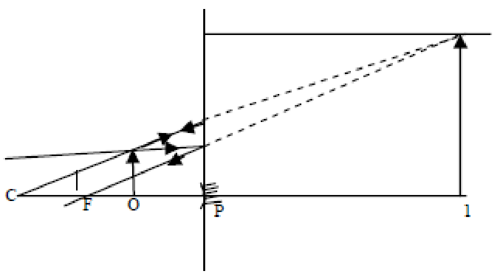


Fig 22
(i) Draw principal axis;

(ii) Draw line to represent mirror at P;
(iii) Mark F and C on a suitable horizontal scale;
(iv) Draw a line parallel to, and above the axis so that the tip of the object is on this line;
(v) Draw a line parallel to, and above the axis behind the mirror so that the tip of the image is on the line. It must be above and behind the mirror because the image is virtual. It must be three times the distance of (iv) from the axis so that the image is magnified three times;
(vi) Draw the ray from the tip of the object parallel to the axis (i.e along (iv)), reflected through F;
(vii) Produce (vi) to cross (v) to give the position of the tip of the image;
(viii) Draw the ray (produced) through the tip of the image and through the tip of the image and through C, which reflects back along its own path;

(ix) Where (viii) crosses (iv) is the tip of the object;
(x) The object is 0.12 m from the mirror.

Or As magnification $= \dfrac{\text{image distance}}{\text{object distance}}$

$3 = \dfrac{\text{image distance}}{\text{object distance}}$

:., image distance = 3 x object distance

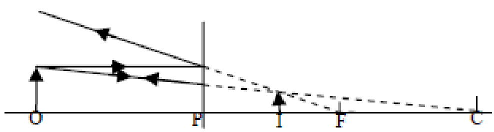
But $\dfrac{1}{\text{object distance}} + \dfrac{1}{\text{image distance}} = \dfrac{1}{\text{focal length}}$

Let object distance = u

:. $\dfrac{1}{u} - \dfrac{1}{3u} = \dfrac{1}{0.18}$ (- as a virtual image)

:. $\dfrac{2}{3u} = \dfrac{1}{0.18}$

:. $u = 0.12$ m



(i) Draw principal axis;
(ii) Draw line to represent mirror at P;
(iii)Mark F and C on a suitable horizontal scale;

(iv)Mark image on same horizontal scale, height does not matter as long as it is not too big;
(v) Draw the path of the reflected ray which, when produced, passes through the tip of the object must be on this line;
(vi)Draw the path of the ray which, when produced, passes through the tip of the image and C. This travels to the mirror and away from it along the same line. The tip of the object must be also on this line;
(vii) Where (v) and (vi) meet is the tip of the object;
(viii) Therefore object is 0.20 m in front of the mirror;
Or Let object distance be u

As $\frac{1}{\text{object distance}} + \frac{1}{\text{image distance}} = \frac{1}{\text{focal length}}$

$\frac{1}{u} - \frac{1}{0.10} = -\frac{1}{0.20}$ (- as virtual image and convex mirror)

:. $\frac{1}{u} = \frac{1}{0.10} - \frac{1}{0.20}$

$= \frac{1}{0.20}$

:. $u = 0.20$ m (in front of mirror)

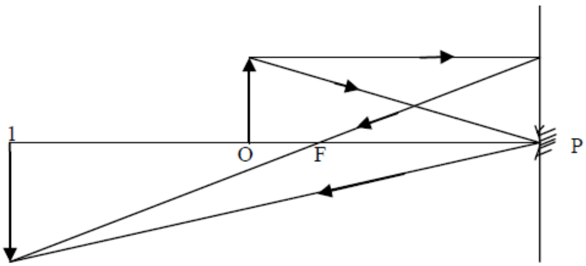


Fig. 24

18.7 (i) Draw principal axis;
(ii) Draw line to represent mirror at P;
(iii) Draw in object and mark image position, on a suitable horizontal scale: vertical height of object is not important;
(iv) Draw a ray from the tip of the object to P, it is reflected at the incident ray was above, because the axis is the normal to the mirror surface at P;
(v) Where (iv) crosses the vertical through I gives the tip of the image;
(vi) Draw a ray from the tip of the object parallel to the principal axis, reflected through the tip of the image;
(vii) where (vi) crosses (i) is F;

(ix) The focal length of the mirror is 0.20 m and the radius of curvature is twice this, i.e. 0,40 m.
Or Let focal length be f

As $\frac{1}{\text{object distance}} + \frac{1}{\text{image distance}} = \frac{1}{\text{focallength}}$

$$\frac{1}{0.30} + \frac{1}{0.60} = \frac{1}{f}$$

$$\frac{1}{f} = \frac{2+1}{0.60} = \frac{3}{0.60}$$

$$= \frac{1}{0.20}$$

:. f = 0.20 m

Radius of curvature = 2f
= 0.40m

18.8 (i) Draw principal axis;
(ii) Draw line to represent mirror at P;
(iii) Draw in object and mark image position, on a suitable horizontal scale: vertical height of object is not important;
(iv) Draw a ray from the tip of the object to P, it is reflected at the incident ray was above, because the axis is the normal to the mirror surface at P;
(v) Where (iv) crosses the vertical through I gives the tip of the image;
(vi) Draw a ray from the tip of the object parallel to the principal axis, reflected through the tip of the image;
(vii) where (vi) crosses (i) is F;
(x) The focal length of the mirror is 0.20 m and the radius of curvature is twice this, i.e. 0,40 m.
Or Let focal length be f

As $\frac{1}{\text{object distance}} + \frac{1}{\text{image distance}} = \frac{1}{\text{focallength}}$

$$\frac{1}{0.30} + \frac{1}{0.60} = \frac{1}{f}$$

$$\frac{1}{f} = \frac{2+1}{0.60} = \frac{3}{0.60}$$

$$= \frac{1}{0.20} = \frac{1}{\text{focal length}}$$

$$\frac{1}{0.10} + \frac{1}{0.40} = \frac{1}{f}$$

$$\therefore \quad \frac{1}{f} = \frac{4+1}{0.40} = \frac{5}{0.40} = \frac{1}{0.080}$$

:. f = 0.080 m

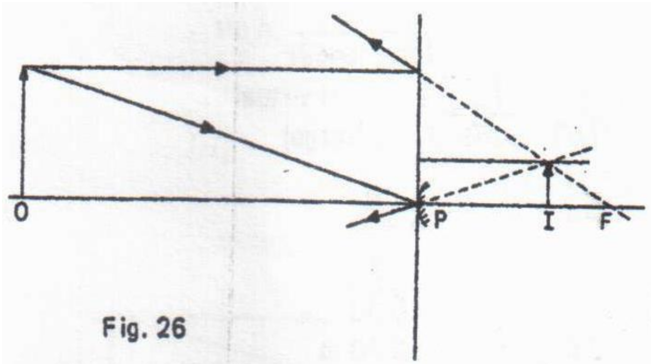


Fig. 26

18.11 (i) Draw principal axis;
(ii) Draw line to represent mirror at P;
(iii) draw in object with a suitable horizontal scale and any convenient height;
(iv) Draw a line parallel to the principal axis above it and behind the mirror, because the image is virtual, and one third of the height of the object from the axis, as the image is diminished three times. The tip of the image is on this line;
(v) Draw a ray from the tip of the object to P, it is reflected at the same angle below the axis as the incident ray was above, because the axis is the normal to the mirror surface at P;
(vi) where the reflected ray in (v) produced back crosses (iv) is the tip of the image;
(viii) where (vii) produced back cuts (i) is F;
(xi) The image is 0.20 m behind the mirror which is of focal length 0.30 m.

Or As magnification $= \dfrac{\text{image distance}}{\text{object distance}}$

$$\frac{1}{3} = \frac{\text{image distance}}{0.60}$$

:. Image distance = 0.20 m

Let focal length = f

And $\dfrac{1}{\text{object distance}} + \dfrac{1}{\text{image distance}} = \dfrac{1}{\text{focal length}}$

$$\frac{1}{0.60} - \frac{1}{0.20} = \frac{1}{f} \text{ (- as virtual image)}$$

$$\therefore \quad \frac{1}{f} = \frac{1-3}{0.60} = \frac{6}{0.60} = \underline{\mathbf{-0.30\ m}}$$

19.1 Let angle of refraction = r

$$\text{As refractive index} = \frac{\sin(\text{angle of incidence})}{\sin(\text{angle of refraction})}$$

$$= \frac{\sin 20.0^0}{\sin r}$$

$$= \frac{0.3420}{1.50}$$

$$= 0.228$$

$$= 13.2^0$$

$$\text{As refractive index} = \frac{\sin(\text{angle of incidence})}{\sin(\text{angle of refraction})}$$

$$= \frac{\sin 54.1^0}{\sin 30.0^0}$$

$$= \frac{0.8100}{0.5000}$$

$$= 1.62$$

$$\text{As refractive index} = \frac{\text{real depth}}{\text{apparent depth}}$$

$$\therefore \quad \frac{4}{3} = \frac{\text{real depth}}{0.90}$$

$$\therefore \quad \text{Real depth} = \frac{4 \times 0.90}{3}$$

$$= \underline{\mathbf{1.20\ m}}$$

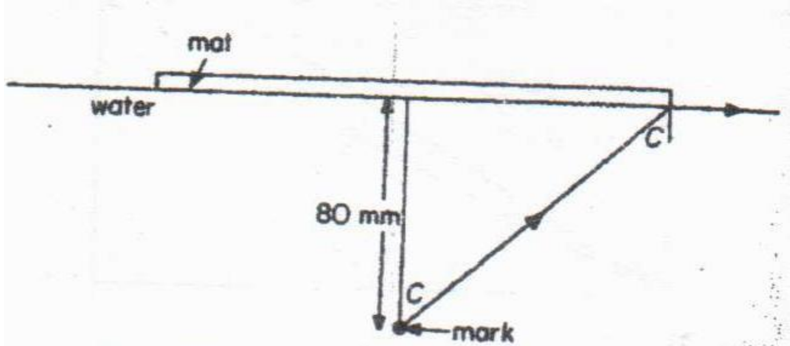


Fig. 27

19.9 The smallest circular mat is the one which makes the angle marked C, the critical angle for the water. Then light from the mark either hits the disc or is reflected; it cannot emerge above the surface.

As refractive index $= \dfrac{1}{\sin(\text{critical angle}}$

$1.33 = \dfrac{1}{\sin C}$

$\sin C = \dfrac{1}{1.33}$

$C = \sin^{-1}(0.7519)$

:. $C = 48.750$

:. $\tan C = 1.100$

but

$\tan C = \dfrac{\text{radius of mat}}{\text{depth of mark}}$

$= \dfrac{\text{radius}}{0.080}$

:. radius $= 0.080 \times 1.1009$

$= 0.088$ m

:. Diameter $= 0.176$ m

= 0.189 m (to 2 fig.)

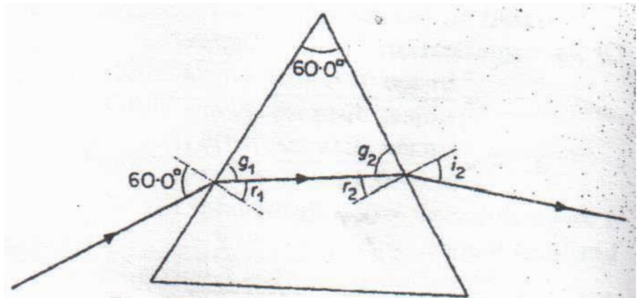


Fig. 28

19.11 At the first face let angle of refraction be r1, and at second face let angle of emergence be i_2. Then as refractive index

$$= \frac{\sin(\text{angle of incidence})}{\text{Sin}(\text{angle of refraction})}$$

$$\therefore \sin r_1 = \frac{\sin 60.0^0}{1.50}$$

$$= \frac{0.8660}{1.5}$$

$$= 0.5773$$

$$\therefore r_1 = 35.27^0$$

$$\therefore \text{Angle } g_1 = 90^0 - 35.27^0$$

$$= 54.730$$

$$\therefore \text{Angle } g_2 = 180^0 - 60^0 - 54.73^0$$

(angle sum of triangle)

$$= 65.27^0$$

$$\therefore \text{Angle } r_2 = 90^0 - 65.27^0$$

$$= 24.73^0$$

But refractive index $= \dfrac{\sin(\text{angle in air})}{\text{Sin}(\text{angle in glass})}$

$$1.50 = \frac{\sin i_2}{\text{Sin } 24.73^0}$$

$$\therefore \text{Sin } i_2 = 1.50 \text{ x } \sin 24.73^0$$

$$= 1.50 \text{ x } 0.4183$$

$$= 0.6275$$

$\therefore i_2 = 38.9^0$

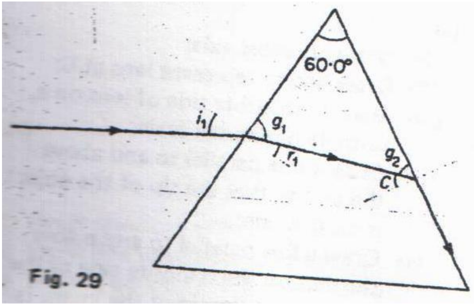


Fig. 29

19.12 Let critical angle = C, angle of refraction at first face = r_1

As refractive index

$$= \frac{1}{\sin(\text{critical angle})}$$

$$1.56 = \frac{1}{\sin C}$$

$$\text{Sin}C = \frac{1}{1.56}$$

$$= 0.641$$

$$\therefore \quad C = 39.87^0$$

$$G_2 = 90^0 - 39.87^0$$

$$= 50.130$$

$$\therefore G_1 = 180 - 60.0^0 - 50.13^0$$

(angle sum of triangle)

$$= 90^0 - 69.87^0$$

$$\underline{\mathbf{= 20.13^0}}$$

And refractive let angle of incidence

$= i_1$

As refractive index

$$\frac{\sin(\text{angle of incidence})}{\sin(\text{angle of refraction})} = \frac{\sin i_1}{\sin 20.13^0}$$

$$\therefore \quad \text{Sin } i_1 = 1.56 \text{ x } \sin 20.130$$

$$= 1.56 \text{ x } 0.3442$$

$$= 0.5369$$

$$\therefore \quad \underline{\mathbf{I_1 = 32.50}}$$

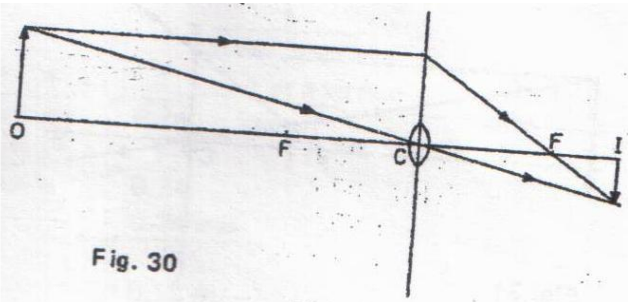


Fig. 30

20.1 (a) (i) Draw principal axis;
(ii) Draw line to represent lens at C;
(iii) Mark F on either side of the lens on a suitable horizontal scale;
(iv) Mark object position and height;
(v) Draw ray from tip of object parallel to principal axis refracted through F;
(vi) Draw ray from tip of object through C which is not deviated;
(vii) Where (v) and (vi) cross is the tip of the image , hence draw in image;
(viii) The image is 0.225 m from the lens, on the opposite side to the object, 10 mm high, inverted and real.

Or let v = image distance

As $\frac{1}{\text{object distance}} + \frac{1}{\text{image distance}} = \frac{1}{\text{focallength}}$

$$\therefore \quad \frac{1}{0.45} + \frac{1}{v} = \frac{1}{0.45}$$

$$\therefore \quad \frac{1}{v} = \frac{1}{0.15} - \frac{1}{0.45}$$

$$= \frac{3-1}{0.45}$$

$$= \frac{2}{0.45}$$

$\therefore$ **V = 0.225 m**

And $\frac{\text{size of image}}{\text{size of object}} = \frac{\text{image distance}}{\text{object distance}}$

$$\therefore \quad \frac{\text{size of image}}{0.020} = \frac{0.225}{0.450}$$

:. Size of image = 0.010 m

So image is 0.225 m from the lens, on the opposite size to the object, 10 mm high, inverted and real.

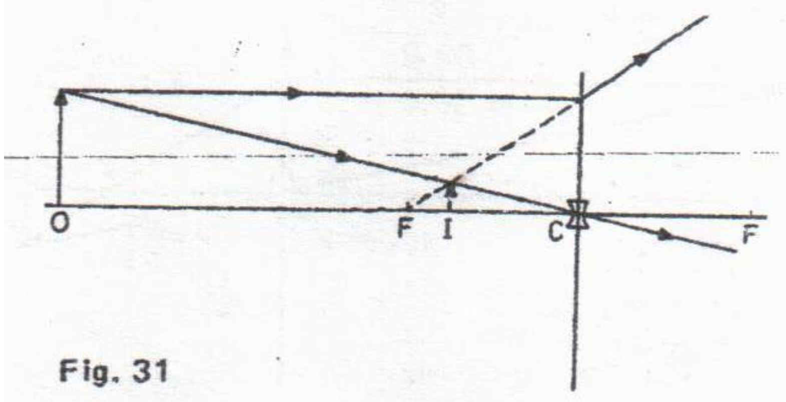


Fig. 31

(b)

(i) Draw principal axis;

(ii) Draw line to represent lens at C;

(iii) Mark F on either side of the lens on a suitable horizontal scale;

(iv) Mark object position and height;

(v) Draw ray from tip of object parallel to principal axis, refracted away from F;

(vi) Draw ray from tip of object through C, which is not deviated;

(vii) where (v) produced back and (vi) cross is the tip of the image, hence draw in image;

(viii) The image is 0.11 m from the lens, on the same side as the object, 5.0 mm high, erect and virtual.

Or Let v = image distance

As $\dfrac{1}{\text{object distance}} + \dfrac{1}{\text{image distance}} = \dfrac{1}{\text{focal length}}$

:. $\dfrac{1}{0.45} + \dfrac{1}{v} = \dfrac{1}{0.15}$ (- as diverging lens)

$= -\dfrac{1}{0.15} - \dfrac{1}{0.45} = \dfrac{-3-1}{0.45} = \dfrac{-4}{0.45} = -\dfrac{0.45}{4}$

<u>= - 0.11 m (to 2 fig.)</u>

And $\dfrac{\text{size of image}}{\text{size of object}} = \dfrac{\text{image distance}}{\text{object distance}}$

:. $\dfrac{\text{size of image}}{0.020} = \dfrac{0.45}{4 \times 0.45}$

:. **<u>Size of image = 0.0050</u>**

So image is 0.11 m from the lens, on the same side as the object, 5.0 mm high, erect and virtual.

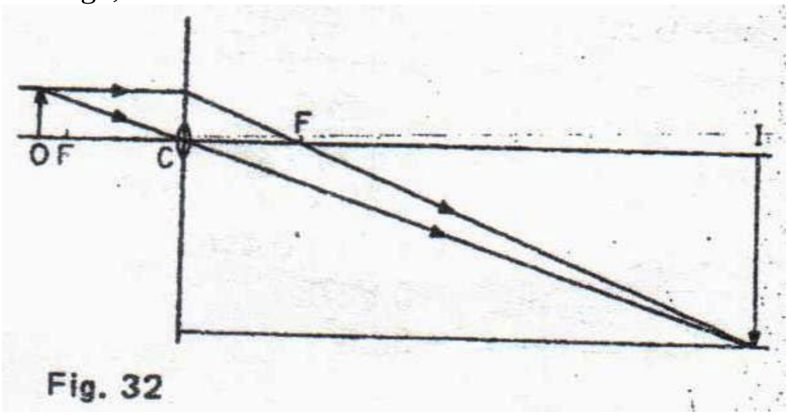


Fig 32

20.2 (a)

(i) Draw principal axis;

(ii) Draw line to represent lens at C;

(iii) Mark F on either side of lens on a suitable horizontal scale;

(iv) Draw a line parallel to and above the axis so that the tip of the object is on this line;

(v) Draw a line parallel to and below the axis on the opposite side of the on lens so that the tip of the image is on this line. It must be below the axis and on the opposite side of the lens because the image is real. It must be four time the distance of (iv) from the axis so that the image is magnified four times;

(vi) Draw the ray from the tip of the object parallel to the axis (i.e along (iv), refracted through F;

(vii) Where (vi) crosses (v) is the tip of the image;

(viii) Draw the undeviated ray through the optical centre and the tip of the image;

(ix) Where (viii) crosses (iv) is the tip of the object;

(x) The object is 0.30 m from the lens.

Or As magnification $= \dfrac{\text{image distance}}{\text{object distance}}$

$$4 = \frac{\text{image distance}}{\text{object distance}}$$

:. Image distance = 4 x object distance

Let object distance = u

As $\frac{1}{\text{object distance}} + \frac{1}{\text{image distance}} = \frac{1}{\text{focal length}}$

$$\frac{1}{u} + \frac{1}{4u} = \frac{1}{0.24}$$

$$\frac{5}{4u} = \frac{1}{0.24}$$

$$U = \frac{0.24 \times 5}{4}$$

$$= 0.18 \text{ m}$$

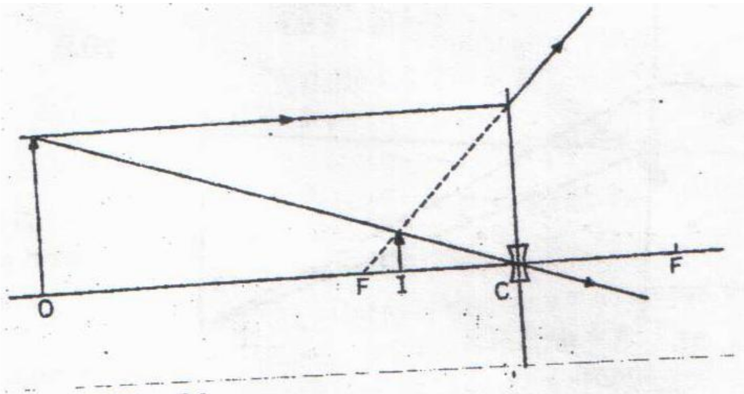


Fig. 34

20.5 (i) Draw line to represent lens at C;
(ii) Draw F on either side of lens on a suitable horizontal scale;
(iv) Mark image on same horizontal scale, height does not matter as long as it is not too big;
(v) Draw the ray which leaves the lens as though it had passed through F and the tip of the image, hence add the incident part of this ray parallel to the axis. The tip of the object must be on this line;
(vi) Draw in the un deviated ray through the tip of the image and C and produce it back. The tip of the object must also be on this line;
(vii) where (v) and (vi) meet is the tip of the object;
(viii) let object distance = u

As $\frac{1}{\text{object distance}} + \frac{1}{\text{image distance}} = \frac{1}{\text{focal length}}$

$\frac{1}{u} - \frac{1}{0.12} = -\frac{1}{0.16}$ (- as virtual image and diverging lens)

$$\therefore \frac{1}{u} = \frac{1}{0.12} - \frac{1}{0.16} = \frac{4-3}{0.48} = \frac{1}{0.48}$$

u = 0.48 m

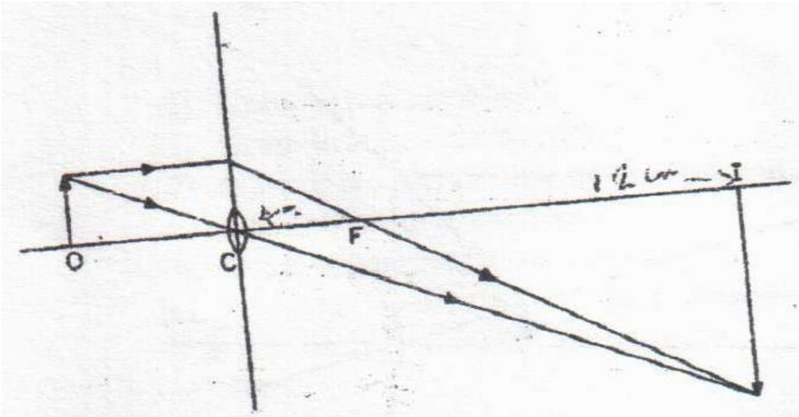


Fig. 35

20.7 (i) Draw principal axis;
(ii) Draw line to represent lens at C;
(iii) Draw in object and mark image position on a suitable horizontal scale; vertical height of object is not important;
(iv) Draw the undeviated ray from the tip of the object through C;
(v) Where (iv) crosses the vertical through I is the tip of the image;
(vi) Draw the ray from the tip of the object parallel to the principal axis and refracted through the tip of the image;
(vii) where (vi) crosses (i) is F;
(viii) The focal length of the lens is 0.19 m.
Or Let focal length be f

$$\text{As } \frac{1}{\text{object distance}} + \frac{1}{\text{image distance}} = \frac{1}{\text{focal length}}$$

$$\frac{1}{0.25} + \frac{1}{0.75} = \frac{1}{f}$$

$$= \frac{3+1}{0.75} = \frac{4}{0.75} = \frac{0.75}{4}$$

$$= \mathbf{0.19\ m\ (to\ 2\ fig.)}$$

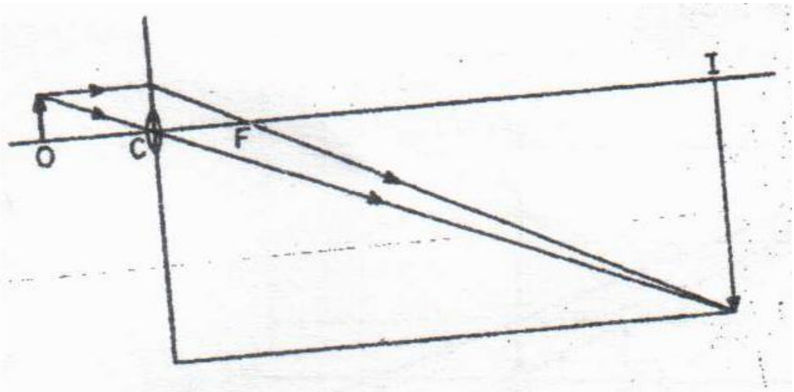


Fig. 36

20.9 (i) Draw principal axis;
(ii) Draw line to represent lens at C;
(iii) Draw in object with a suitable horizontal scale and any convenient height;
(iv) Draw a line parallel to the principal axis but below it and on the opposite side of the lens as the image is real, and five times the height of the object from the axis as the magnification is five. The tip of the image is on this line.
(v) Draw the undeviated ray from the tip of the object through C;
(vi) Where (iv) crosses (v) is the tip of the image;
(vii) Draw a ray from the tip of the object parallel to the principal axis, refracted through the tip of the image;
(viii) Where (vii) crosses (i) is F;
(ix The focal length of the lens is 0.10 m.

Or As magnification $= \dfrac{\text{image distance}}{\text{object distance}}$

:. $5 = \dfrac{\text{image distance}}{0.12}$

:. Image distance $= 5 \times 0.12$

$= 0.60$ m

Let focal length $= f$

As $\dfrac{1}{\text{object distance}} + \dfrac{1}{\text{image distance}} = \dfrac{1}{\text{focal length}}$

$$\frac{1}{0.12} + \frac{1}{0.60} = \frac{1}{f}$$

$$\therefore \quad \frac{1}{f} = \frac{5+1}{0.60}$$

$$= \frac{6}{0.60}$$

$$\therefore \quad f = \frac{0.60}{6}$$

$$= \mathbf{0.10\ m}$$

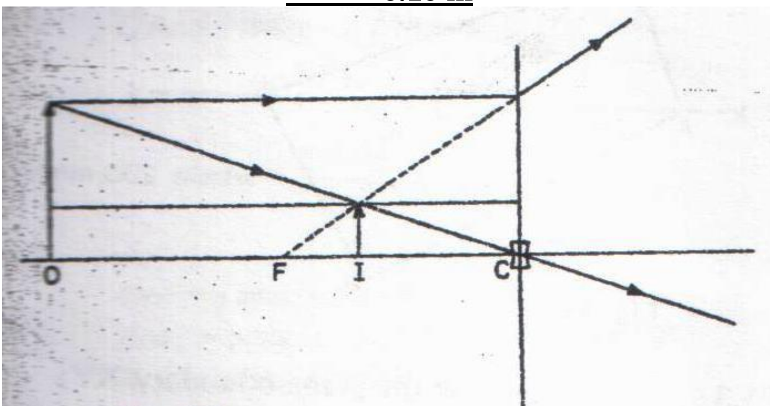


Fig. 37

20.10 (i) Draw principal axis
(ii) Draw line to represent lens at C;
(iii) Draw in object with a suitable horizontal scale and any convenient height;
(iv) Draw a line parallel to the principal axis, above it and on the same side of the lens as the image is virtual, and one third of the height of the object from the axis as the image is diminished three times. The tip of the image is on this line;
(v) Draw the undeviated line from the tip of the object through C;
(vi) Where (v) crosses (iv) is the tip of the tip of the image;
(vii) Draw a ray from the tip of the object parallel to the principal axis, refracted as though it had passed through the tip of the image;
(viii) where (vii) produced back cuts (i) is F;
(ix) The image is 0.060 m from the lens, which is of focal length 0.090 m.

Or As magnification $= \dfrac{\text{image distance}}{\text{object distance}}$

$$\frac{1}{3} = \frac{\text{image distance}}{0.18}$$

:. Image distance = 0.060 m

Let focal length = f

$$\text{And} \quad \frac{1}{\text{object distance}} + \frac{1}{\text{object distance}} = \frac{1}{\text{focallength}}$$

$$\frac{1}{0.18} - \frac{1}{0.060} = \frac{1}{f} \quad \text{(-as a virtual image)}$$

$$:. \quad \frac{1}{f} = \frac{1-3}{0.18}$$

$$= \frac{-2}{0.18}$$

f = -0.090 m

20.13 Let focal length = f

$$\text{As} \quad \frac{1}{\text{object distance}} + \frac{1}{\text{image distance}} = \frac{1}{\text{focallenght}}$$

$$\frac{1}{4.00} + \frac{1}{0.129} = -\frac{1}{f}$$

$$:. \quad 025 + 7.75 = -\frac{1}{f}$$

$$:. \quad \frac{1}{f} = 8.00$$

f **= <u>0.125 m</u>**

20.15 let object distance = u, image distance = v, and focal length = f

$$\text{As magnification} = \frac{\text{image distance}}{\text{object distance}}$$

$$20 = \frac{v}{u}$$

:. V = 20u

And as distance from slide to screen is 8.40 m

U + v = 8.40

:. U + 20u = 8.40

:. 21u = 8.40

:. U = 0.40 m

:. V = 8.00 m

And $\frac{1}{\text{object distance}} + \frac{1}{\text{image distance}} = \frac{1}{\text{focal length}}$

$$\frac{1}{0.40} + \frac{1}{8.00} = \frac{1}{f}$$

$$\frac{1}{f} = \frac{20+1}{8.00}$$

$$f = \frac{8.00}{21}$$

$$= \mathbf{0.38\ m\ (to\ 2\ fig.)}$$

Late image distance = v

As $\frac{1}{\text{object distance}} + \frac{1}{\text{image distance}} = \frac{1}{\text{focal length}}$

$$\frac{1}{0.20} + \frac{1}{v} = \frac{1}{0.15}$$

$$\therefore \frac{1}{v} = \frac{1}{0.15} - \frac{1}{0.20}$$

$$= \frac{4-3}{0.60}$$

$$= \frac{1}{0.60}$$

$\therefore$ **v = 0.60 m**

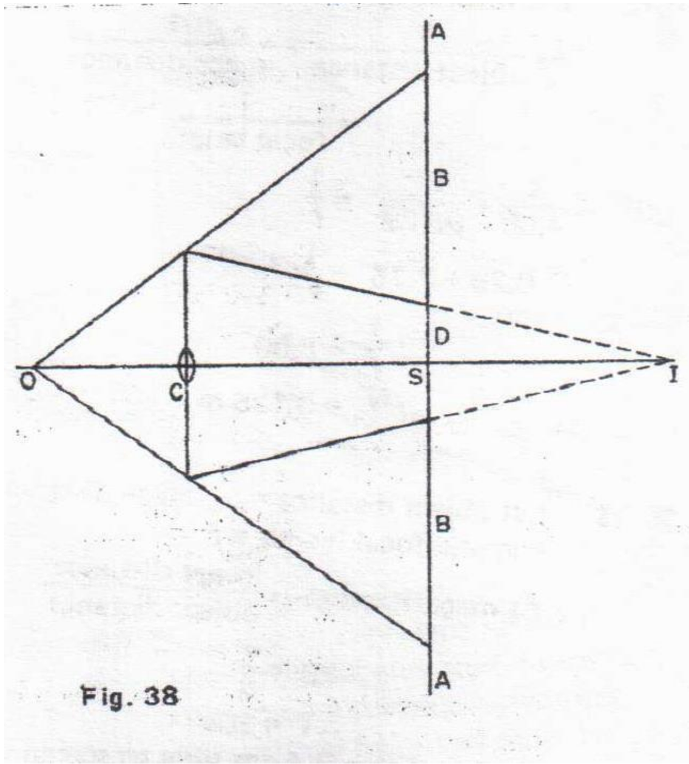


Fig. 38

Now
(i) Draw principal axis;
(ii) Draw in line to represent lens and mark on lens size;
(iii)Mark in object and image position on a suitable horizontal scale,
(iv)Draw rays from object to either edge of lens refracted to image;
(v) Mark in screen position;
(vi)Region A on the screen is unaffected by the lens, and region B of outside diameter 0.150 m is dark, and region C is bright as the light falling on to the lens is refracted into that region. It is of 0.030 m diameter.
Thus there is a bright disc surrounded by a dark ring on the screen.
21.1 Let wavelength = λ
As velocity = wavelength x frequency

$$300 = \lambda \times 1100$$

$$\therefore \lambda = \frac{330}{1100}$$

$$\underline{= 0.30 \text{ m}}$$

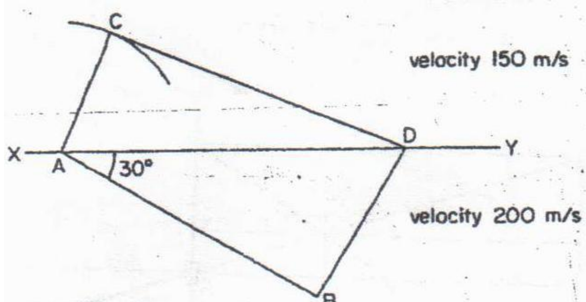


Fig. 39

21.3 (i) Draw in the plane boundary XY;
(ii) Draw the wave front AB at an angle of 300 to XY;
(iii) Mark B such that BD (perpendicular to AB) is 40 mm long (representing velocity to scale).
Now, while the wave front at B is traveling to D, that from A will only travel 150/200 as far, because the wave travels with 150/200 of its original velocity in the second medium,
So
(iv) Draw an arc of a circle centre A radius 30 mm, to represent the extreme position of the wave front;
(v) Draw a tangent from D to (iv). This is the new wave front;
(vi) The angle made by the wave front to the surface is $\angle ADC = 22^0$.

21.5 As
Grating spacing x sin (angle of diffraction) = order of spectrum x wavelength Now grating spacing $= \frac{1(\text{metre})}{\text{number of lines per metre}}$

$= \frac{1}{200\,000}$

And wavelength of green light = 500 nm
= 0.000 000 500 m

:. For green light, let angle of diffraction = θ_1

And $\frac{1}{200\,000}$ x sin θ_1= 1 x 0.0000000000000000000000000 000 500 m

:. Sin θ1 = 0.000 000 500 x 200 000
= 0.100

:. θ_1 = 5.730

For red light, let angle of diffraction

= θ_2

And $\frac{1}{200\,000}$ x sin θ_2 = 0.000 000 700

:. Sin θ_2 = 0.000 000 700 x 200 000

= 0.140

:. θ_2 = 8.05^0

:. Angle between colours = θ_2 - θ_1

= 8.050 – 5.730

= 2.30 (to 2 fig.)

21.7 As,Grating spacing x sin (angle of diffraction) = order of spectrum x wavelength

Now grating spacing = $\frac{1(\text{metre})}{\text{number of lines per metre}}$

= $\frac{1}{400000}$

Wavelength of violet light = 400 nm

= 0.000 000 400 m

And maximum angle of diffraction

= 90^0

So if order of spectrum is n = $\frac{1}{200000}$ x sin 90^0

= n x 0.000 000 400

:. n = $\frac{\sin 90^0}{400000 \times 0.000\,000400}$

:. n = $\frac{1}{0.160}$

= **6.25**

But n must be a whole number so 6 orders can be observed.

22.1 Let resistance of resistor be R

Use resistance = $\frac{\text{potential difference}}{\text{current}}$

(a) R = $\frac{12}{3.0}$ = 4.0 Ω

(b) R = $\frac{12}{0030}$ = 4 000 Ω

(c) R = $\frac{12}{0.000\,0030}$ = 4 000 000 Ω

$= \quad 4.0\ \text{M}\ \Omega$

22.3 Let current be /

Use current $= \dfrac{\text{p.d.}}{\text{resistance}}$

(a) / = $\dfrac{40}{20}$ $=$ 2.0 A

(b) / = $\dfrac{0.004}{20}$ $=$ 0.000 2 A

$=$ 200 μ A

(c) / = $\dfrac{4}{20}$ $=$ 0.2 A

$=$ **200 mA**

22.4 Let potential difference be V

Use potential difference = current x resistance

(a) V = 5.0 x 100 = 500 v

(b) V = 0.050 x 100 = 5.0 V

(c) V = 0.000 000 50 x 100

= 0.000 050 v

= 50 μ V

22.7 As resistance $= \dfrac{\text{potential difference}}{\text{current}}$

$= \dfrac{50}{020} = 2500\ \Omega$

So length of wire $= \dfrac{\text{total resistance}}{\text{resistance per metre}}$

$= \dfrac{2500}{4}$

= 625 m

= **630. m (to 2 fig.)**

23.1 (a) In parallel

$$\frac{1}{\text{total resistance}} = \frac{1}{\text{resistance}_1} + \frac{1}{\text{resistance}_2}$$

$$= \frac{1}{6} + \frac{1}{3} = \frac{1+2}{6} = \frac{3}{6}$$

:. Total resistance $= \dfrac{6}{3} = 2\ \Omega$

(b) In series, total resistance = $resistance_1 + resistance_2$

= $6 + 3$

= $9\ \Omega$

In parallel.

$$\frac{1}{\text{total resistance}} = \frac{1}{\text{resistance}_1} + \frac{1}{\text{resistance}_2} + \frac{1}{\text{resistance}_3}$$

$$= \frac{1}{6} + \frac{1}{3} + \frac{1}{2}$$

$$= \frac{1+2+3}{6} = \frac{6}{6} = 1$$

:. Total resistance = 1 Ω

In parallel.

$$\frac{1}{\text{affective resistance}} = \frac{1}{\text{resistance}_1} + \frac{1}{\text{resistance}_2}$$

$$= \frac{1}{25} + \frac{1}{50} = \frac{2+1}{50} = \frac{3}{50}$$

:. Effective resistance

$$= \frac{50}{3}$$

$$= 16.7\ \Omega$$

And total resistance is effective resistance of parallel pair + third resistance = $16.7 + 10$ = 26.7

= **27 Ω (to 2 fig.)**

As the resistors are in parallel the 6.8 V is acting across each resistor.

As current = $\dfrac{\text{potential difference}}{\text{resistance}}$

So for 10 Ω resistor,

Current = $\dfrac{6.8}{17}$ = 0.40 A

23.9 For the 5.0 Ω resistor

Current = $\dfrac{\text{potential difference}}{\text{resistance}}$

$$= \frac{10}{5.0} = 2.0\ \text{A}$$

For the two resistors in parallel

$$\frac{1}{total\ resistance} = \frac{1}{resistance_1} + \frac{1}{resistance_2}$$

$$= \frac{1}{16} + \frac{1}{24}$$

$$= \frac{3+2}{48}$$

$$= \frac{5}{48}$$

$$= 9.6\ \Omega$$

:. So potential difference across these resistors = total current x total resistance

$$= 2.0 \times 9.6$$

$$= 19.2\ V$$

And this acts across both of the resistors

As current = $\frac{potential\ difference}{resistance}$

So for 16 Ω resistor, current = $\frac{19.2}{16}$ = 1.2 A

And for 24 Ω resistor, current = $\frac{19.2}{24}$ = 0.8 A

(Check 1.2 + 0.8 = 2.0)

23.10 Let resistance required be R

As $\frac{1}{total\ resistance} = \frac{1}{resistance_1} + \frac{1}{resistance_2}$

$$\frac{1}{30} = \frac{1}{75} + \frac{1}{R}$$

$$:.\quad \frac{1}{R} = \frac{1}{30} - \frac{1}{75}$$

$$= \frac{5-2}{150}$$

$$= \frac{3}{150}$$

$$:.\quad R = \frac{150}{3}$$

$$= \quad 50\ \Omega$$

23.13 As

$$\frac{1}{\text{total resistance}} = \frac{1}{\text{resistance}_1} + \frac{1}{\text{resistance}_2} + \frac{1}{\text{resistance}_3}$$

$$= \frac{1}{12} + \frac{1}{6} + \frac{1}{4}$$

$$= \frac{1+2+3}{12} = \frac{6}{12} = \frac{1}{2}$$

:. Total resistance = 2 Ω

:. Potential difference across group = total current x total resistance

= 0.6 x 2

= 1.2 V

And this acts across all of the resistors

$$\text{As current} = \frac{\text{potential difference}}{\text{resistance}}$$

So for 12 Ω resistors, current $\frac{1.2}{12} = 0.1$ A

For 6 Ω resistor, current = $\frac{1.2}{6} = 0.2$ A

And for 4 Ω resistor, current

$$= \frac{1.2}{4} = 0.3 \text{ A}$$

(check 0.1 + 0.2 + 0.3 = 0.6)

24.1 As resistively $= \dfrac{\text{resistance x area}}{\text{length}}$

$$= \frac{0.40 \text{x } 0.000\,002}{1}$$

= 0.000 000 80 Ω m

= 0.80 $\mu\Omega$ m

24.3 As area $= \dfrac{\text{resistivity x length}}{\text{resistance}}$

$$= \frac{0.000\,000\,60 \text{x } 15}{4.5}$$

= 0.000 0020 m^2

= $2.0\ mm^2$

24.5 As length = $\frac{\text{resistance x area}}{\text{resistivity}}$

= $\frac{5.0 \text{ x } 0.000\,0008}{0.000\,000\,40}$

= 10 m

24.7 As resistance = $\frac{\text{resistivity x length}}{\text{area}}$

In second case = $\frac{\text{resistivity x length x } 3}{\text{area x } 4}$

= $\frac{8.0 \text{ x } 3}{4}$

= $6.0\ \Omega$

25.1 Let current be /

As e.m.f. = current x total resistance

2.0 = / x (0.50 + 3.50)

/ = $\frac{2.0}{4.0}$

= 0.50 A

As potential difference

= current x resistance

= 0.50 x 3.50

= =1.75 V

25.3 Let current be /

As e.m.f. = current x total resistance

10.0 = / x (2.0 + 3.0 + 5.0)

= / x 10.0

= 1.0 A

And p.d. = current x external resistance

= 1.00 x (3.0 + 5.0)

= 8.0 V

25.5 For the two resistors in parallel

= $\frac{1}{\text{resistance}_1} + \frac{1}{\text{resistance}_2}$

= $\frac{1}{15.0} + \frac{1}{10.0}$

$$= \frac{2+3}{30.0}$$

$$= \frac{5}{30.0}$$

:. Total resistance

$$= \frac{30.0}{5} = 6.0\ \Omega$$

In whole circuit, let current be /.

E.m.f. = current x total resistance

:. 8.0 = / x (6.0 + 2.0)

:. / = 1.0 A

So potential difference across parallel

= current x total resistance

= 1.0 x 6.0

= 6.0 V

But this potential difference acts across each resistor

:. Current in 15.0 Ω resistor

$$= \frac{\text{potential difference}}{\text{resistance}}$$

$$= \frac{6.0}{15.0}$$

= 0.40 A

Similarly current in 10.0 Ω resistor

$$= \frac{6.0}{10.0}$$

= 0.60 A

(check 0.40 + 0.60 = 1.0)

For two resistors in parallel.

$$\frac{1}{\text{effective resistance}} = \frac{1}{\text{resistance}_1} + \frac{1}{\text{resistance}_2}$$

$$= \frac{1}{8.0} + \frac{1}{8.0}$$

$$= \frac{2}{8.0}$$

$$= \frac{1}{4.0}$$

:. Effective resistance

$$= \frac{1}{4.0}$$

$= 4.0\ \Omega$

So for whole circuit, let current be I.

And e.m.f = current x total resistance

14.0 = I x (1.0 + 2.0 + 4.0

= I x 7.0

:. I = 2.0 A

And p.d. across 2.0 Ω resistor

= Current x resistance

= 2.0 x 2.0

= 4.0 V

With batteries acting together, (let current be I I) total e.m.f.

= sum of individual e.m.f.'s

= 2.0 + 1.0

= 3.0 V

And total e.m.f.

= current x total resistance

3.0 = I_1 x (0.50 + 2.50 + 1.00)

= I_1 x 4.00

:. I_1 = 0.75 A

With batteries opposed, (let current be I2) total e.m.f

= difference of individual e.m.f's

= 2.0 – 1.0

= 1.0 V

N.B total resistance does not change so as, total e.m.f

= current x total resistance

1.0 = I_2 x 4.00

I_2 = 0.25 A

:. Change in current

= I_1 - I_2

= 0.50 A

25.11 Total e.m.f of battery

= e.m.f of one cell x number of cells

= 2.0 x 10

= 20 V

Total resistance of battery

= resistance of one cell x number of cells

= 0.10 x 10

= 1.0 Ω

The resulting potential difference

= supply p.d. – battery e.m.f.

= 30 – 20

= 10 V

As circuit resistance

$= \dfrac{\text{potential difference}}{\text{current}}$

$= \dfrac{10}{2.0}$

= 5.0 Ω

:. Resistance needed

= circuit resistance – battery resistance

= 5.0 – 1.0

= 4.0 Ω

26.1 To convert the milliammeter into an ammeter, a low resistance is connected in parallel

(a)

If the meter is to give a f.s.d. the current through it must be 0.0010 A, so the shunt current is 1.0 – 0.0010 = 0.999 0 A.

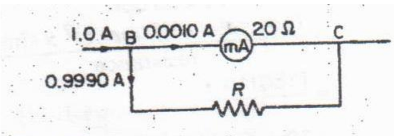


Fig. 40

Let the shunt resistance be R Then as potential difference

= current x resistance

For path via meter;

= 0.0010 X 20

= 0.999 X R

But these are the same p.d.

:. 0.0010 x 20 = 0.999 x R

:. *R* $= \dfrac{20}{999}\ \Omega$

26.3 To convert the milliammeter into a voltmeter, a high resistance is connected in series.

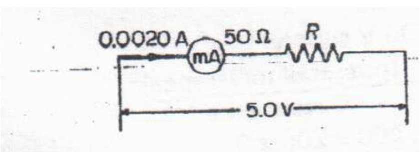


Fig. 41

(a)
If the meter is to give a f.s.d. the current through it must be 2.0 m A when the maximum potential difference of 5.0 V is applied across the meter and series resistor (let value of resistor be R) As potential difference

$$= \text{current x total resistance}$$
$$5.0 = 0.0020 \times (R + 50)$$
$$R + 50 = \frac{5.0}{0.0020}$$
$$= 2500$$
$$\therefore R = 2450\ \Omega$$

(b) Similarly

$$250 = 0.0020 \times (R + 50)$$
$$\therefore R + 50 = \frac{250}{0.002}$$
$$= 125\,000$$
$$\therefore R = 124\,950$$
$$= 125\,000\ \Omega \text{ (to 3 fig.)}$$

27.1 As mass = e.c.e. x current x time
$$= 0.000\,000\,33 \times 1.0 \times 3\,600$$
$$= 0.001\,188 \text{ kg}$$
$$= 1.2 \text{ g (to 2 fig.)}$$

27.3 Let time be t

As mass = e.c.e x current x time
$$0.000\,099 = 0.000\,000\,33 \times 3.0 \times t$$
$$T = \frac{0.000099}{0.00000099}$$
$$= 100 \text{ s}$$

27.5 Let true current be /

As mass = e.c.e x current x time
$$0.000\,330 = 0.000\,000\,33 \times / \times 500$$
$$/ = \frac{0.000\,330}{0.000\,00033 \times 500}$$
$$= \frac{1\,000}{500}$$
$$= 2.0 \text{ A}$$

So error
= indicated reading – true current

= 2.1 – 2.0
= 0.1 A

27.6 Volume of metal deposited
= area x thickness
= 2 x 0.0020 x 0.000 10
= 0.000 000 40 m^3

:. Mass of metal deposited
= volume x density
= 0.000 000 40 x 7200
= 0.002 88 kg

Let time needed be t
Then as mass = e.c.e x current x time
0.002 880 = 0.000 000 50 x 2.0 x t

$$T = \frac{0.002\,880}{0.000\,001}$$

= 2 880 s
= 48 min.

27.9 Mass of hydrogen
= e.c.e. x current x time
= 0.000 000 011 x 2.0 x t

$$:.\ t = \frac{0.0022 \times 0.090}{0.000\,000022}$$

= 100 000 x 0.090
= 9 000 s
= 150 min.

27.10 Let e.c.e be e
Then as mass = e.c.e x current x time
0.000 12 = e x 0.5 x 12000

$$e = \frac{0.0012}{600}$$

= 0.000 000 20 kg/C

27.11 As mass $\alpha \dfrac{\text{relative atomic mass}}{\text{valency}}$

$$= \frac{\text{constant x relative atomic mass}}{\text{valency}}$$

:. For copper 0.000 477

$$= \frac{\text{constant x } 63.6}{2}$$

:. For zinc, mass

$$= \frac{\text{constant x } 65.4}{2}$$

Divide (2) by (1)

$$\frac{\text{mass (of zinc)}}{0.000477 -} = \frac{65.4}{63.6}$$

:. Mass of zinc $= \frac{65.4 \text{ x } 0.000477}{63.6}$

= 0.000 491 kg

= 0.491 g

As energy converted = current x potential Difference x time

= 10 x 4.0 x 300

= 12 000 J

= 12 kJ

Let time required be t

Energy required

= mass x specific heat capacity x rise in temperature = 0.800 x 4200 x (43 – 18)

= $(\text{current})^2$ x resistance x time

= $(5.0)^2$ x 8.4 x t

:. t $= \frac{0.800 \text{ x } 4.200 \text{ x } 25}{25 \text{ x } 8.4}$

$$= \frac{0.800 \text{ x } 4.200}{8.4}$$

= 0.800 x 500

= 400 s

28.5 Let time required be f Energy required

= mass x specific latent heat

= 0.100 x 2250 000

$$= \frac{(\text{potential difference})^2 \text{ x time}}{\text{resistance}}$$

$$= \frac{(150)^2 \text{ x t}}{10}$$

$$\therefore \quad T = \frac{10 \times 10.100 \times 2250\,000}{(150)^2}$$

$$= \frac{2\,250000}{225000}$$

$$= 100 \text{ s}$$

28.7 As power $= \dfrac{\text{energy}}{\text{time}}$

Mass x specific heat capacity = $\dfrac{\text{x rise in temperature}}{\text{time}}$

$$= \frac{2.4 \times 4200 \times 10}{300}$$

= 0.8 x 42 x 10

= 336 W

= 340 W (to 2 fig.)

28.9 As power

= current x potential difference

2 000 = current x 250

Current = 8.0 A

$\therefore$ resistance $= \dfrac{\text{potential difference}}{\text{current}}$

$$= \frac{250}{8.0}$$

And on 200 V supply

Power $= \dfrac{(\text{potential difference})^2}{\text{resistance}}$

$$= \frac{200 \times 200 \times 8}{250}$$

= 8 x 20 x 8

= 1 280 W

= 1.3 kW (to 2 fig.)

28.10 Energy used = Power x time

= 2.0 x 10

= 20 kilowatt hours

= 20 units

Cost = number of units x price per unit

= 20 x 2

= 40 p

28.13 (a) Resistance

$$= \frac{\text{potential difference}}{\text{current}}$$

$$= \frac{240}{8.0}$$

$= 30\ \Omega$

(b) Power

= current x potential difference

= 8 x 240

= 1 920 W

= 1.9 kW (to 2 fig.)

(c) Energy used

= power x time

= 1.92 x 20

= 38. 4 units

Cost = number of units x price per unit

= 38.4 x 1.5

= 57.6 pence

= 58 pence (to 2 fig.)

29.1 Initial count rate = 1200 per second

:. After 1st half life period

= 600 per second

:. After 2nd half life period

= 200 per second

:. 9 a.m, Monday to 12 noon next

Wednesday = 4 + 24 + 24

= 52 hours is 2 half lives

:. Half life = 26 hours

29. 3 If initial count rate = 2400 per second

After 1 st half life period

= 1200 per second

After 2nd half life period

= 600 per second

:. After 3rd half life period

= 300 per second

:. 3 half-lives, or 6.0 hours needed

:. Time = 5.00 p.m.

29.5 An alpha particle is ${}^{4}_{2}He$

So the mass number drops four to 212 and the atomic number drops two to 82

216 212 4

$$\therefore \quad {}_{84}\mathrm{Po} \rightarrow {}_{82}\mathrm{Pb} + {}_{2}\mathrm{He}$$

ANSWERS

N.B. Numbers in square brackets [ ] are not significant.

4 000 kg/m^3
20 kg/m^3
0.20 m
40 m
0.000 10 m^3
0.000 50 m^3
1200 kg/m^3
950 kg/m3
(a) 3 Alcohol : 1 Water
(b) 2.4 Alcohol : Water

1: 1.8
200 g
0.75 kg

75 cm mark
0.2 m from other end
78 cm mark
0.1 m from other end
6.0 N
1.5 N
100 g
160 g

660 N, 310 N
24[4] N; 35[6] N
0.12 [5] m
2 000 N
1.100 kg
8.0 kg
0.18 m from centre of larger sphere
0.77 mm from centre of larger cube

3.8 75%
3.9 40%
3.10 800 W
3.11 1 600 J
3.12 27 kJ
3.13 20%
13.14 25%

4.1 14 [7 00] N/m^2
4.2 0.010 m^2
4.3 101 [333] N/m^2; 10 mm
4.4 200 mm; 101 [568] N/m2
4.5 800 kg/m3
4.6 112 mm
4.7 680 m
4.8 522 mm

5.1 68.[24] N
5.2 64. [12] N
5.3 69. [6] N; 40 [4] N
5.4 7.0 [2] N; 6.9 [8] N
5.5 3 000 kg/m^3
5.6 5 000 kg/m^3
5.7 5 000 kg/m^3; 2 000 kg/m^3
5.8 4 000 kg/m^3; 1400 kg/m^3
5.9 1 500 kg/m^3; 1500 kg/m^3
5.10 600 kg/m3; 83(3.3) kgm3
5.11 333.[2] N
5.12 548.(8) N

1.4 mm from centre of original disc
1.3 [92] mm from centre of sphere
9.0 N; 0.8 m from end where 5 N force
Applied
5.0 N; 0.4 m from end where 3 N force
Applied
5.19 4700 kg
80%
62. [5] %
150 N
270 N
17[60] N
4 400 N
200 N
6.1 5.4 N; N 112^0 E
6.2 6.4 m; N 51. [3] 0W
6.3 2.9 N
6.4 32.[6] N
6.5 104.5^0 from river flow 15. [46] s
6.6 N 2.8 [7]^0 W; 0.50 [05] h
6.7 0.31 [5] N
6.8 4.0 [47] N

7.1 10 m/s^2
7.2 - 12 m/s^2
7.3 190 m
7.4 50 m
7.5 1.5 m/s ^{2}
7.6 18 m/s ^{2}
7.7 20.0 m/s
7.8 14 m/s
7.9 11.0 (25) m
7.10 12 (2.5) m
7.11 82. (5) m
7.12 9.6 m

8.1 0.4 m/s ^{2} ; 1.2 m/s
8.2 0.6 m/s ^{2} ; 2.4 m/s
8.3 6.1 (25) m/s ^{2}
8.4 5.8 (8) m/s ^{2}
8.5 1.9 (6) m/s ^{2}

5.13 65. [2] cm mark
5.14 16.[9] cm mark
5.15 750 kg/m^3
5.16 600 kg/m^3
5.17 0.15 m
5.18 54 g

5.20 16
5.21 0.9 kg
5.22 15.[9] kg
5.23 1.6 [67] kg
5.24 3500 kg
5.25 68 [6] N
5.26 150 kg
9.14 300 N
9.15 18 m
9.16 8 m/s

10.1 0.15 m/s
10.2 1.2 [5] m/s
10.3 1.0 m/s
10.4 1 m/s
10.5 6.0 m/s; 86 [4] kJ
10.6 6.0 m/s; 70 [.2] kJ

11.1 1.001 [2] m
11.2 0.803 [6] m
11.3 510 ^{0}C
11.4 - 30 ^{0}C
11.5 7776 (.6) kg/m ^{3}
11.6 8311 kg/m ^{3}
11.7 125 (.2) ^{0}C
11.8 70 ^{0}C
11.9 1.058 (8) m
11.10 0.111(1) m
11.11 3.009 mm
11.12 100 ^{0}C

12.1 30 ^{0}C
12.2 -10 ^{0}C
12.3 180 ^{0}C

8.6	6.00 kg
8.7	50 m/s ^{2}
8.8	40 m/s ^{2}
8.9	11980)N
8.10	47 (6) N
8.11	0.8
8.12	0.2
8.13	(a) 1.9 (6) m/s ^{2}
	(b) 1.1(76) m/s ^{2}
8.14	(a) 5.8 (8) m/s ^{2}
	(b) 5.4 (88) m/s ^{2}
9.1	19 (60) J
9.2	47 (04) J
9.3	405 kJ
9.4	50 J
9.5	2.4 kW
9.6	980 W
9.7	31(.8) Kj
9. 8	25(.2) kJ
9. 9	1.9(6) kW
9.10	50
9.11	9.8Kw
9.12	1 in 28 (8)
9.13	4 000 N
14.1	(a) 76(4) kJ
	(b) 1.0(16) MJ
	(c) 6.1(04) MJ
14.2	(a) 1.2 (72) MJ
	(b) 2.0 (28) MJ
	(c) 9.2 (82) MJ
14.3	8.2 (5) ^{0}C
14.4	25(.5) ^{0}C
14.5	18(.03) ^{0}C
14.6	12 (.99) ^{0}C
14.7	68 (.2) ^{0}C

12.4	-150 ^{0}C
13.1	46 ^{0}C
13.2	62 ^{0}C
13.3	37 (.4) ^{0}C
13.4	84.7 ^{0}C
13.5	25 (.1) ^{0}C
13.6	19 (.15) ^{0}C
13.7	20 (.7) ^{0}C
13.8	10 (.63)
13.9	420 J/kg K
13.10	840 J/kg K
13.11	59 (2) ^{0}C
13.12	350 ^{0}C
13.13	600W
13.14	2.1kW
13.15	2.5 min
13.16	15 min
13.17	6.6 (3) min
13.18	10 (96) W
13.19	A
13.20	Iron
13.21	500 J/kg K
13.22	2000 J/kg K
15.15	(a) 90 000 N/m ^{2}
	(b) 72 (900) N/m ^{2}
15.16	(a) 99 000 N/m ^{2}
	(b) 98 (010) N/m ^{2}
16.1	(a) 160 000 N/m ^{2}
	(b) 0.16 m ^{3}
16.2	(a) 120 000 N/m ^{2}
	(b) 0.20 m ^{3}
16.3	Reduced to $\frac{2}{3}$ original
16.4	0.018 m ^{3}

14.8 15 (.3) ^{0}C
14.9 1.7 (8) kg
14.10 1.0 (52) kg
14.11 0.21(1) kg
14.12 -100 ^{0}C
14.13 10 (2) min
14.14 100W
14.15 200 ^{0}C
14.16 69 g
14.17 65 (6 000) J/kg
14.18 1 600 J/kg K
14.19 0.60kg
14.20 68 W
14.21 (a) 42 min
(b) 11 (2.5) min
14.22 (a) 12 (.6) min
(b) 37(.3) min
14.23 (a) 3.1 min
(b) 11(.3) min
14.24 (a) 11 (.3) min
(b) 4.3 (9) min

15.1 (a) 0.000 5 m^3
(b) 50 000 N/m^2
15.2 (a) 0.0012 m^3
(b) 40 000 N/m^2
15.3 (a) 52 (.5) mm
(b) 60 mm
15.4 (a) 40 mm

16.5 0.068 2(5) m^3
16.6 177 (.45) cm^3
16.7 3.0 kg/ cm^3
16.8 0.20 (25) kg/ m^3
16.9 47 (7) ^{0}C
16.10 13 (27) ^{0}C
16.11 30 ^{0}C
16.12 363 mmHg

17.1 50 mm
17.2 80 mm
17.3 1.5 m
17.4 0.012(5) m
17.5 1.0 m from source
17.6 3.0 m from source

18.1 (a) 0.086 m, behind mirror
4.3 mm high, erect, virtual
(b) 0.60 min in front of mirror
30 high, inverted, real
18.2 (a) 0.15 m behind mirror
5 mm high, erect, virtual
(b) 0.30 m in front of mirror
10 mm high, inverted, real
18.3 (a) 0.24 m; (b) 0.12 m
18.4 0.20 m; (b) 0.12 m
18.5 0.20 m
18.6 0.20 m
18.7 0.20 m; 0.40 m
18.8 0.17 (646) m; 0.35 (2 92) m

(b) 42 (.2) mm
15.5 0.000 009 m^3
15.6 31 (.5) m
15.7 4.8 (8) m
15.8 30.1(8) m
15.9 4.5 kg
15.10 10.5 kg
15.11 375 mm
15.12 746 mmHg
15.13 740 mmHg
15.14 780 mm
19.7 1.2 m
19.8 0.28 m
19.9 0.17 (6) m
19.10 122 (.47) mm
19.11 38.9°
19.12 38.7°
19.13 32.5°
19.14 36.3°

20.1 (a) 0.225 m, opposite side
10 mm high, inverted, real
(b) 0.11(25) m, same side
5.0 mm high, erect, virtual
20.2 (a) 0.33(3) m, opposite side, 20 mm high,
Inverted real
(b) 0.14(3) m, same side
8.6(3) mm high, erect virtual
20.3 (a) 0.30 m; (b) 0.18 m
20.4 (a) 0.20 m; (b) 0.10 m
20.5 0.48 m
20.6 0.37 (5) m
20.7 0.18(75) m
20.8 0.22 (5) m
20.9 0.10 m
20.10 0.12 m
20.11 0.60 m; -0.090 m
20.12 0.090 m; -0.12 m

18.9 0.080 m
18.10 0.12 (5) m
18.11 0.20 m behind mirror; -0.30 m
18.12 0.1 m behind mirror -0.13(3) m

19.1 13.2°
19.2 46.6 (5)°
19.3 1.62.
19.4 1.62 (3)
19.5 1.47
19.6 1.55 (6)
23.1 (a) 2Ω (b) 9 Ω
23.2 (a) 6 Ω (b) 25 Ω
23.3 1 Ω
23.4 3 Ω
23.5 26(.7) Ω
23.6 10 Ω
23.7 0.68 A; 0.40 A
23.8 2.0 A; 0.70 A

23.9 1.2 A; 0.8 A; 2.0 A
23.10 0.16 A; 0.24 A; 0.40 A
23.11 50 Ω
23.12 90 Ω
23.13 0.1 A; 0.2 A; 0.3A.
23.14 30 Ma; 45 Ma; 75 mA
24.1 0.80 μΩm
24.2 0.20 μΩm
24.3 2.0 mm^2
24.4 0.24 mm^2
24.5 10 m
24.6 50 m
24.7 6.0Ω
24.8 24 Ω

25.1 0.50A; 1.7(5) V
25.2 0.50 A; 5.5 V
25.3 1.0 A; 8.0V

20.13	0.125 m	25.4	2.0 A; 11 V
20.14	151 (.5) mm	25.5	0.40 A; 0.60 A
20.15	0.38 (1) m	25.6	1.0 A; 2.0 A
20.16	0.24 (2) m	25.7	4.0 V
20.17	Bright disc 0.030 m diam.,surrounded by	25.8	16V
	Dark ring 0.150 m outside diameter	25.9	0.50 A
20.18	Bright disc 0.030 m diam., surrounded by	25.10	1.6 A
	Dark ring 0.210 m outside diameter	25.11	4.0 Ω
21.1	0.30 m	25.12	9.0 Ω
21.2	2.0 m		
21.3	22°	26.1	(a)
$^{20}/_{999}\,\Omega$ (b) $^{20}/_{999}\,\Omega$			
21.4	24.2 (3)°	26.2	(a)
$^{5}/_{99}\,\Omega$ (b) $^{5}/_{999}\,\Omega$			
21.5	2.3 (2)	26.3	(a) 24 [50] Ω (b) 124
[950] Ω			
21.6	2.6 (1)	26.4	(a) 99 000 Ω (b) 99 (9
000) Ω			
21.7	6		
21.8	2	27.1	1.1 [88] g
22.1	(a) 4.0 Ω; (b) 4.0 k Ω; (c) 4.0 M Ω	27.2	4.3 (2) g
22.2	(a) 2.0 M Ω; (b) 200 Ω; (c) 20 Ω	27.3	100s
22.3	(a) 2.0 A; (b) 200 μA; (c) 200mA	27.4	160s
22.4	(a) 2.0 Ma; (b) 200Ma; (c) 20μA	27.5	0.1 A
22.5	(a) 500 V; (b) 5.0 V; (c) 50μV	27.6	0.05 A
22.6	(a) 560 V; (b) 56 V; (c) 560 m V	27.7	48 min
22.7	62 (5) m	27.8	23 (0.4) min
22.8	20 m	27.9	150 min
		27.10	450s
27.11	0.000 000 20 kg/C	27.12	0.000 000 15 kg/C
27.13	0.491 g	27.14	0.72 g
28.1	12 Kj	28.2	11 (.52)Kj
28.3	400s	28.4	500s
28.5	100s	28.6	33 (3.3) s
28.7	33(6) W	28.8	25(2) W
28.9	1.2 (8) kW	28.10	24 (3) kW
28.11	40 p	28.12	60 p
28.13	(a) 30 Ω; (b) 1.9 (2) kW; (c) 57 (.6) p	28.14	(a) 12(5) Ω; (b) 500 W;
(c) 2 p			
29.1	26 hr	29.2	9 hr
29.3	5.00 p.m.	29.4	1.40 p.m.

29.5 $^{216}_{84}po \rightarrow ^{212}_{82}pb + ^{4}_{2}He$ 29.6

$^{177}_{71}Lu \rightarrow ^{177}_{72}Hf + ^{o}_{-1}e$