Kenya Certificate of Secondary Education
2017 Physics paper 1

SECTION A

1. In order to determine the size of an oil molecule, a student performed an experiment using five oil drops to make a circular patch of the oil on the surface of water in a waterbath. State two assumptions made by the student during the calculations. (2 marks)
   - zero loss of oil molecules during the transfer process, hence volume (say V) of the oil remains constant
   - the oil forms a perfect circular patch (say radius r) and
   - the oil patch is one molecule thick (say d), then the volume of the five drops of oil is equal to the volume of the circular oil patch (basically a cylinder that is one molecule thick), that is;
2. In an experiment to determine the density of Liquid R. a student obtained the followed data:
   - Mass of an empty density bottle = 55.0 g
   - Mass of the density bottle + water = 80.0 g
   - Mass of the density bottle + Liquid R = 70.0 g.

   Determine the density of Liquid R. (density of water is 1000 kgm^{-3} (3 marks)

   Density is defined as mass of a substance divided by its volume, that is;

   $$Density = \frac{mass}{volume} \quad \text{(i)}$$

   The density (D_R) of liquid R is therefor given by:

   $$D_R = \frac{mass\ of\ R}{Volume\ of\ R} \quad \text{(ii)}$$

   Mass of R is easy to obtain since;

   $$mass\ of\ R = mass\ of\ density\ bottle\ and\ R - mass\ of\ density\ bottle$$

   Working with mass in kg (SI units);

   $$Mass\ of\ R = 0.070 - 0.055 = 0.015\ kg \quad \text{(iii)}$$

   Volume of R on the other hand cannot be obtained in such a straight forward manner. We however know that the density bottle will hold a liquid that is equal to its volume hence:

   $$volume\ of\ R = volume\ of\ density\ bottle \quad \text{(iv)}$$

The volume of the density bottle is not provided in the question. We however know that;

$volume\ of\ density\ bottle = volume\ of\ water\ it\ can\ hold$ (v)

From definition of density, it follows that;

$volume\ of\ water(V) = \frac{mass\ of\ water}{density\ of\ water}$ (vii)

$V = \frac{massof\ water\ and\ density\ bottle - mass\ of\ density\ bottle}{density\ of\ water}$ (viii)

$V = \frac{0.080 - 0.055}{1000} = \frac{0.025}{1000}$ (ix)

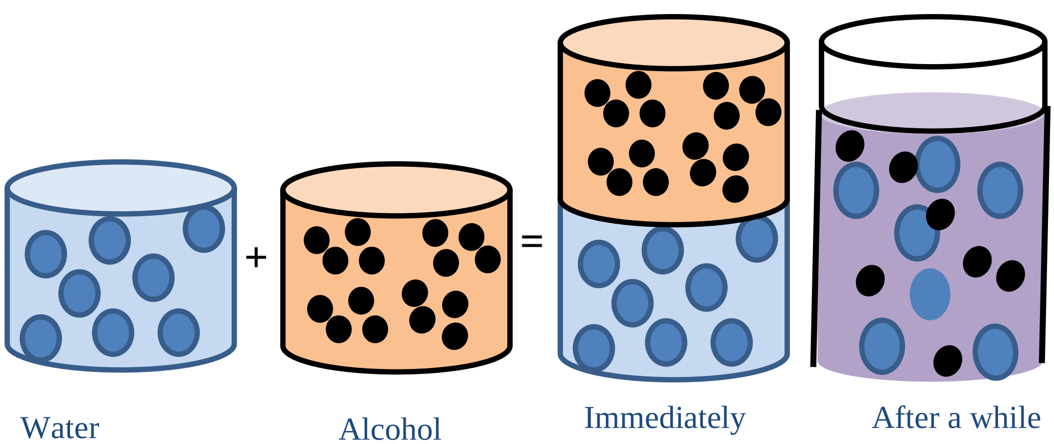
$V = 0.000025 \frac{kg}{m^3} = \ volume\ of\ R$ (x)

Hence;

$D_R = \frac{mass\ of\ R}{Volume\ of\ R} = \frac{0.015}{0.000025} = 600\ kg/m^3$ (xi)

3. It is observed that when 20 cm^3 of alcohol is mixed with 20 cm^3 of water, the volume of the mixture is 39 cm^3. State a reason why the volume of the mixture is not 40 cm^3. (1 mark)

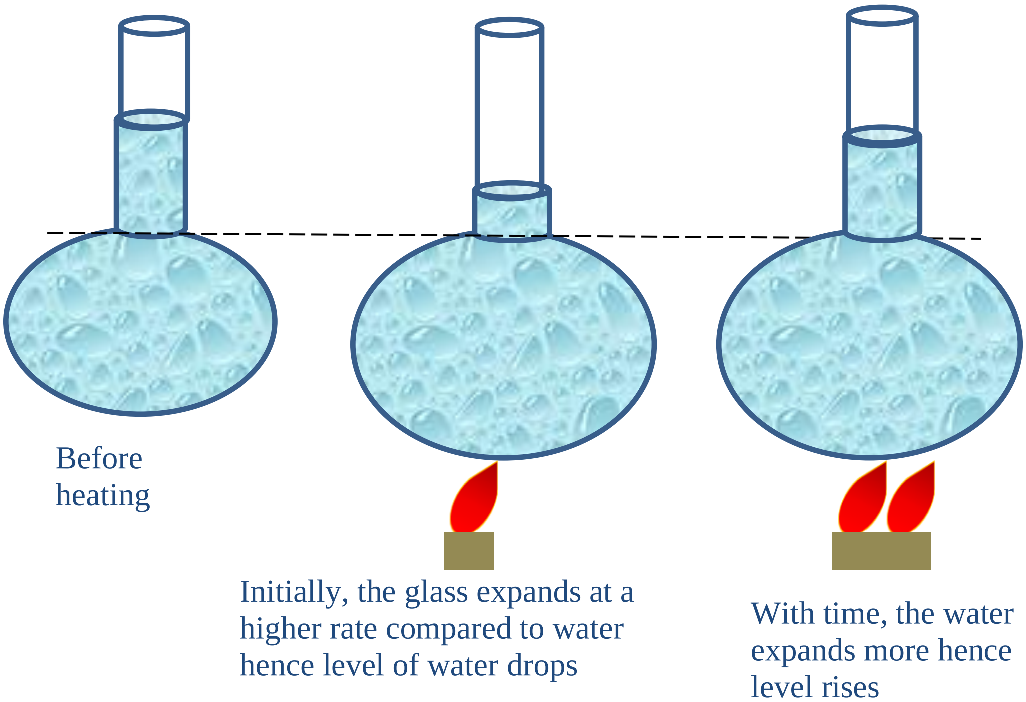
   Water has larger molecules hence larger inter-molecular spacing compared to alcohol. After mixing, some of the alcohol molecules occupy the spaces between the water molecules. The volume of the mixture is thus less than the total volume of the water and the alcohol before mixing.



4. When a liquid is heated in a glass flask, it is observed that the level at first goes down and then rises. Explain this observation. (2 marks)

   When a liquid (say water) and a solid (say glass) are subjected to the same temperature, the solid absorbs heat at a higher rate compared to the liquid.

Objects expand when heated and as such glass will expand at a higher rate compared to a liquid hence the initial reduction of liquid level. As the liquid gains more heat, it expands more and the level goes up.



5. Figure 1 shows a uniform wooden bar at equilibrium with two cans Y and Z of equal mass but different diameters.

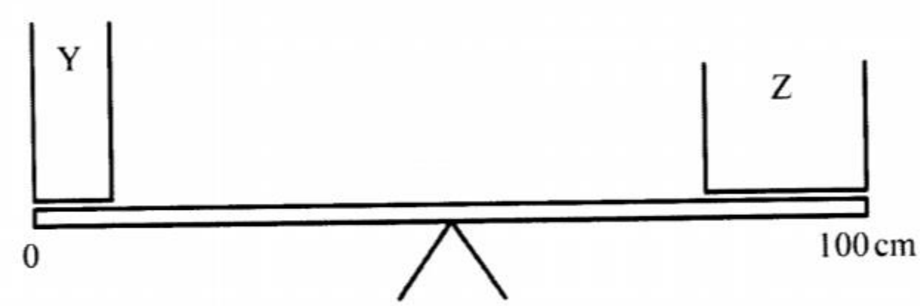


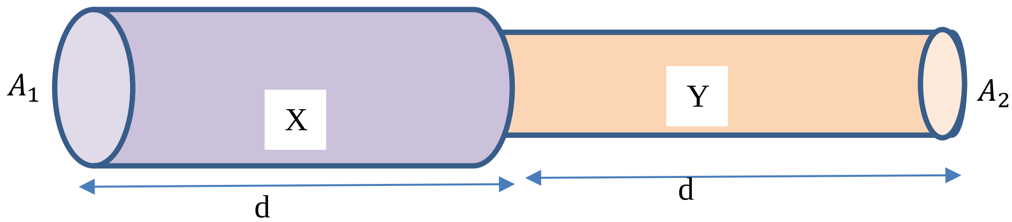
Figure 1

The cans are simultaneously filled with equal volumes of water. Explain the observation made. (2 marks)

The fact that the wooden bar is in equilibrium (before water is introduced) means that the two cans are exerting equal forces downwards hence no turning effect. Equal volumes of water have the same mass and when simultaneously introduced, the cans still exert equal forces downwards and no turning effect occurs. The wooden bar therefore remains in equilibrium.

6. State the reason why the speed of water at the narrow section of a river is higher than at the wider section. (1 mark)

   Let A_1 and A_2 be the cross-sectional areas of the wider and smaller sections of the river respectively.



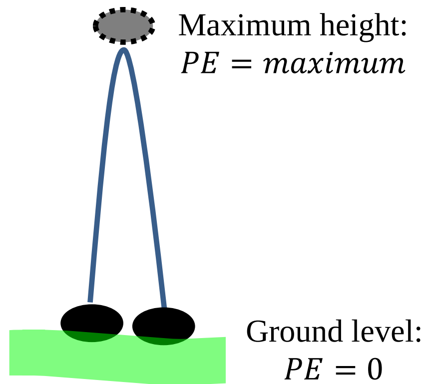
   Let v_1 and v_2 be the speed of water in the wider and narrow sections of the river respectively. The volume flow-rates in both sections of the river are equal hence;

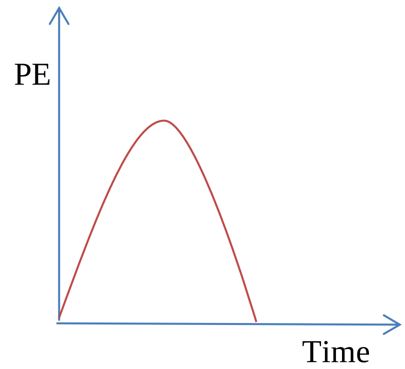
   $A_1 v_1 = A_2 v_2$

   This is only possible if the speed of water in the thinner section is higher.

7. A stone is thrown vertically upwards. Sketch a graph of potential energy (y axis) against time as the stone moves until it hits the ground. (1 mark)

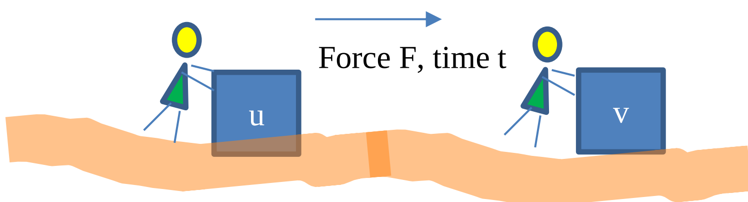
   Potential energy (PE) increases with distance above the earth's surface, with PE on the earth's surface (ground) taken to be zero. When a ball is thrown up in the air, the distance between the ball and the ground increases hence the PE energy increases as the ball moves up. The ball however slows down as it moves up due to the effect of gravity, coming to a momentarily stop at some maximum distance (height) from the earth's surface. At this maximum height the ball has maximum PE. The ball then starts moving downwards under the influence of gravity, with the distance to the ground, and hence the PE, reducing with time. The PE drops to zero when the ball hits the ground.





8. Using the definition of impulsive force. show that F = ma (3 marks)

Impulse is defined as the product of the resultant force and the time in which it acts. Impulse is also defined as change in **momentum** (momentum is the product of mass and velocity) of a body. Say a force F acts on a body of mass m for a time t causing its velocity to change from u to v.



From the definition of momentum, it follows that;

$Impulse = Ft$ (i)

$Impulse = Change\ in\ momentum = mv - mu$ (ii)

Equations (i) and (ii) are equivalent hence;

$Ft = mv - mu$ (iii)

$F = m\left(\frac{v-u}{t}\right)$ (iv)

But $\frac{v-u}{t} = a$ (acceleration) (v)

Hence

$F = ma$ (vi)

9. Figure 2 shows a round bottomed flask fitted with a long capillary tube containing a drop of coloured water.

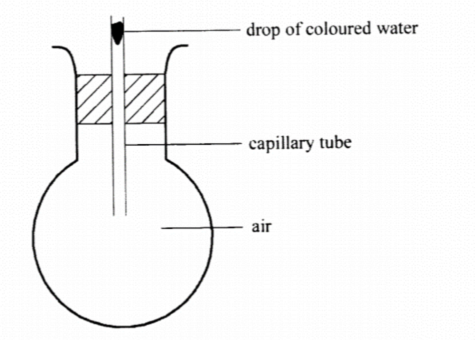


Figure 2

The flask is immersed in ice water for some time. State the observation made. (2 marks)

When the flask is immersed in ice water, the air in the flask cools down (temperature reduces) and contracts (volume reduces) leading to a reduction in gas pressure. The higher atmospheric pressure pushes the ink drop further down into the capillary tube. When the flask is removed from the ice water, the temperature of the air in the flask increases, pressure increases, volume increases, ink drop is pushed up ($pV \propto T$).

10. State one assumption for the experiments carried out to verify the gas laws. (1 mark)

    Air in the flask is an ideal gas (ideal gas is a gas that perfectly obeys the gas laws)
    The flask, the capillary tube and the ink drop do not loose/gain heat and therefore they do not contract/expand.

11. A student who wanted to take a bath mixed 4 kg of water at 80 °C with 6 kg of water at 20 °C. Determine the final temperature of the water. (3 marks)

$Heat\ lost\ by\ hot\ water = 4 \times c \times (80 - \theta)$

$Heat\ gained\ by\ cold\ water = 6 \times c \times (\theta - 20)$

$Heat\ lost = heat\ gained$

$4 \times c \times (80 - \theta) = 6 \times c \times (\theta - 20)$

$4(80 - \theta) = 6(\theta - 20)$

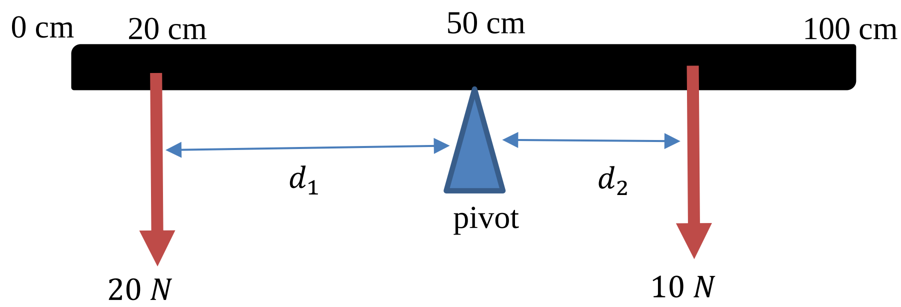
$320 - 4\theta = 6\theta - 120$

$320 + 120 = 6\theta + 4\theta$

$10\theta = 440$

$\theta = \frac{440}{10} = 44^0C$

12. A uniform metre rule is pivoted at its centre. Two weights of 20N and 10 N are suspended at the 20cm and 100cm marks respectively. Determine the position at which a 10N weight should be suspended in order to balance the system. (3 marks)



Since:

$d_1 = 50 - 20 = 30\ cm$

Then by equation (ii)

$20 \times 30 = 10 \times d_2$

$600 = 10d_2$

$d_2 = \frac{600}{10} = 60$ cm

The 10 N force should be placed 60 cm from the pivot. This corresponds the 90 cm mark on the meter rule.

13. Figure 3 shows two possible designs of a three-legged stool.

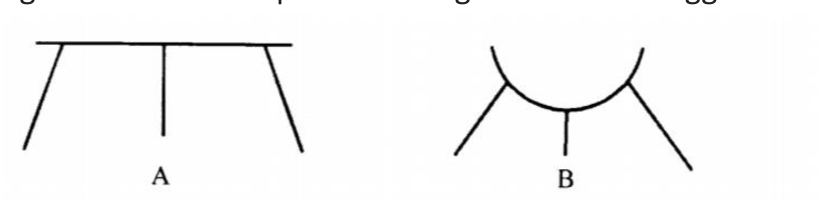


Figure 3

State a reason why B is more stable than A.

B is more stable because it has a lower **center of gravity (cog)**.

Section B:

14. (a) A tape attached to an accelerating trolley passes through a ticker timer that makes dots on it at a frequency of 50Hz. The ticker timer makes 10 dots on a 10cm long tape such that; the distance ***a*** between the first two dots is 0.5 cm and the distance ***b*** between the last two dots is 1.5 cm.

(i) Determine the velocity of the trolley at:

(I) distance a, (4 marks)

$frequency = \frac{1}{period}$

$Period\ (T) = \frac{1}{frequency}$

Hence;

$T = \frac{1}{50} = 0.02\ s$

$Initial\ speed\ (u_a) = \frac{distance\ between\ two\ consecutive\ dots}{period}$

$u_a = \frac{0.5\times10^{-2}}{0.02} = 0.25\ m/s$

Alternatively;

$speed = (dist\ betwn\ two\ consec\ dots) \times frequency$

$v_a = 0.5 \times 10^{-2} \times 50 = 0.25\ m/s$

(II) distance b. (2 marks)

$Final\ speed\ (v_b) = dist.\ between\ two\ cons.\ dots) \times frequency$

$v_b = 1.5 \times 10^{-2} \times 50 = 75 \times 10^{-2} = 0.75\ m/s$

(ii) Determine the acceleration of the trolley (3 marks)

$a = \frac{v_b - u_a}{t}$

To find acceleration, we need to find time. We know that;

$total\ dist = average\ vel \times t$

and;

$average\ speed = \frac{v_b + u_a}{2}$

Hence;

$total\ dist = \frac{v_b + u_a}{2} \times t$

$0.1 = \frac{0.75+0.25}{2} t = 0.5t$

$t = \frac{0.1}{0.5} = 0.2\ s$

(Alternatively, can use; $time = no.\,of\ dots \times period = 10 \times 0.02 = 0.2\ s$)

By equation (i);

$$a = \frac{0.75 - 0.25}{0.2} = \frac{0.5}{0.2}$$

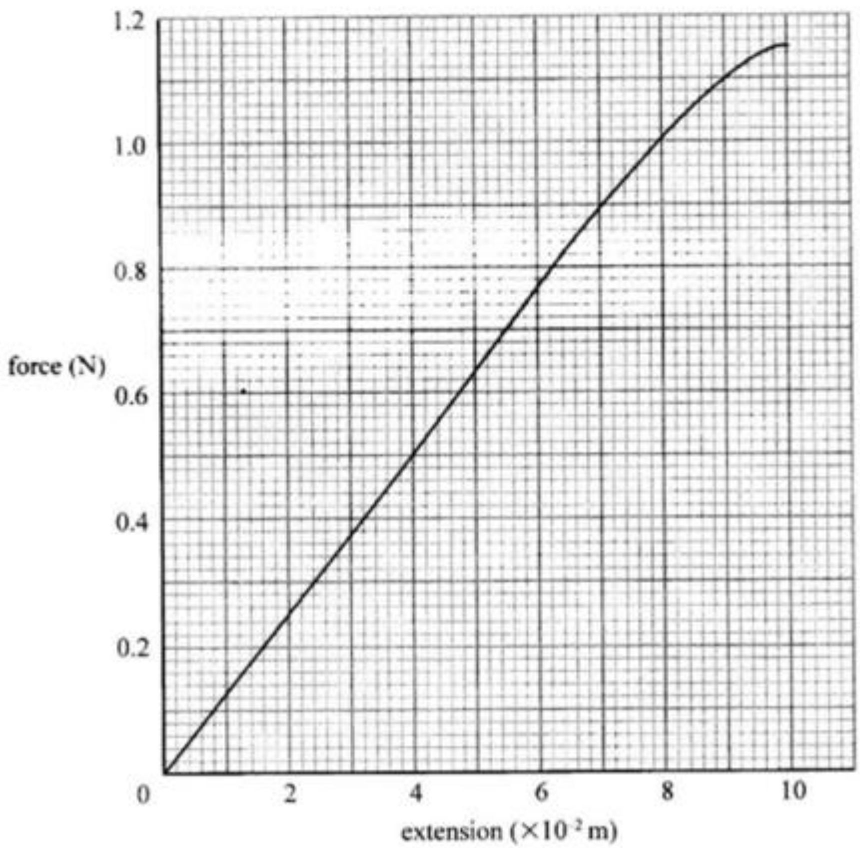
$a = 2.5\ m/s^2$

(b) state with reason what would be observed on the spacing between the dots if on the tape if the trolley is made to move on a horizontal surface. (2 marks)

- If frictional force was negligible, then the net force on the trolley would be zero hence the trolley would move at a constant velocity (zero acceleration). The dots would be equally spaced.
- If on the other hand the frictional force was present, the speed of the trolley would reduce with time hence the spacing between the dots would reduce with time.

15. (a) A student was provided with several identical masses, a metre rule, a spring and a stand, boss and clamp. Outline five steps that the student should follow in order to verify Hooke's law. (5 marks)
    - Measure length of spring
    - Suspend first mass, measure the new length
    - Determine the extension ($new\ length - original\ length$)
    - Keep adding more masses and noting the new extension (e)
    - Plot a graph of weight ($F = mg$) against extension and determine the gradient (k)
    - Hooke's law: $F = ke$

    (b) Figure 4 shows a graph that was drawn from the results obtained in an experiment to study the extension of a spring.



From the graph determine:

(i) The spring constant K. (3 marks)

$$k = gradient = \frac{\Delta y}{\Delta x} = \frac{0.5}{10^{-2}} = 12.5\ N/m$$

(ii) The load that causes an extension of 3×10^{-2} m. (1 mark)

Use formula,

$F = k \times e$

$F = 12.5 \times 3 \times 10^{-2}$

$F = 0.375\ N$

or get answer directly from graph

(c) Three identical springs of spring constant 100 Nm^{-1} are arranged as shown in Figure 5 to support a 5N load.

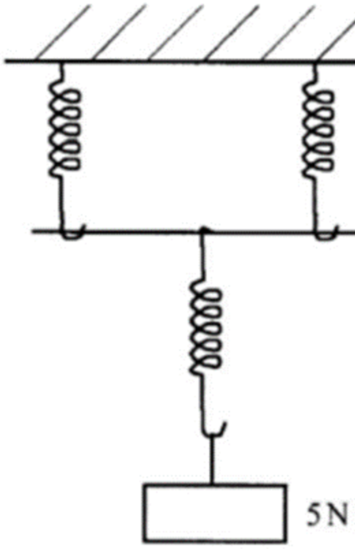


Figure 5

Determine the total extension for the arrangement.

$$k_{12} = k_1 + k_2 = 100 + 100 = 200$$

$$k = \frac{k_{12}k_2}{k_{12} + k_3} = \frac{200 \times 100}{200 + 100} = \frac{200}{3}$$

$$e = \frac{F}{k} = 5 \times \frac{3}{200} = 0.075 \text{ m}$$

16. (a) In an experiment to determine the size of an oil molecule, oil is placed on the surface of water after sprinkling lycopodium powder on it.

(i) State two reasons why oil is used. (2 marks)

- Oil being less dense floats on water (no mixing)
- Oil easily spreads on water due to the high adhesive force and therefore capable of forming a very thin layer (mono-layer) of oil.

(ii) State the function of the lycopodium powder. (1 mark)

- Allows for a clear view of the oil boundary
- Prevents oil from mixing with water

(iii) State any two assumptions that are made in this experiment. (2 marks)

- Patch is monolayer (one molecule in diameter)
- The oil drop has a spherical shape (for ease of calculating its volume)
- The oil patch is perfectly circular
- No loss of oil during transfer

(iv) Explain why the oil spreads on the surface of water. (2 marks)

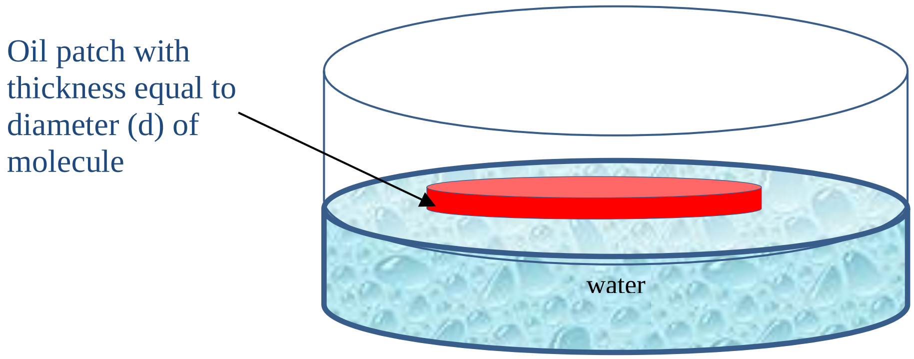
Oil is less dense hence does not sink. The greater adhesive force reduces the surface tension of water.

(b) The following data was obtained from an experiment to determine the size of a palm oil molecule.

— Volume of 100 drops of palm oil = $15.0mm^3$

— Area of a patch from one drop of oil = $8.0 \times 10^4 mm^2$

Determine the size of a palm oil molecule. (3 marks)



$Volume\ of\ 1\ drop = \frac{15}{100} = 0.15\ mm^2$ (i)

$volume\ of\ the\ oil\ patch = volume\ of\ the\ oil\ drop$ (ii)

The oil patch is cylindrical, one molecule thick (d) hence;

$volume = \pi r^2 d = 0.15$ (iii)

But;

$\pi r^2 = area$ (iv)

Hence;

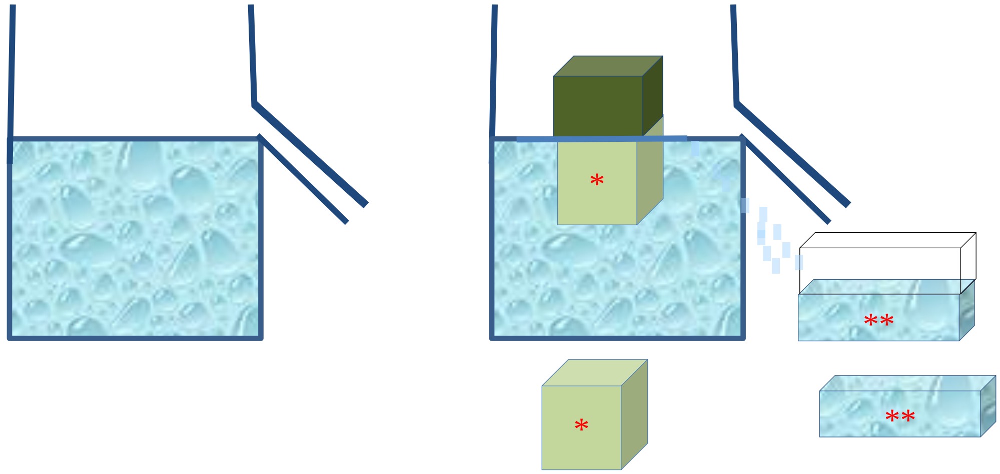
$area \times d = 0.15$ (v)

$8 \times 10^4 d = 0.15$ (vi)

$d = \frac{0.15}{8\times10^4} = 1.875 \times 10^{-6}\ mm$ (vii)

17. (a) State the law of flotation. (1 mark)

Law of floatation: a floating body displaces a fluid equal to the weight of part of the body submerged and is equal to upthrust.



Law of floatation: Weight of * = weight of **

(b) Figure 6 shows two solids W and X made of the same material and immersed in water.

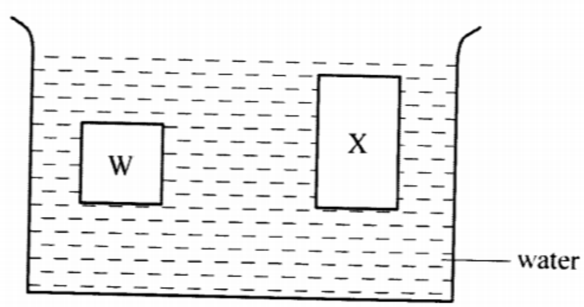


Figure 6

(i) State with a reason which one of the containers experiences a greater upthrust? (2 marks)

X because the larger the body submerged the greater the upthrust.

(ii) Solid W weighs 12N in air. 2N in water and 4 N in another liquid. Determine the density of the other liquid. (3 marks)

$Density = \frac{mass}{volume}$

To find density of the other liquid, we need to find its mass and volume. Now;

$upthrust\ = weight\ of\ liguid\ displaced\ (W_{liquid})$

$upthrust = weight\ in\ air - weight\ in\ the\ liquid$

$W_{liquid} = 12 - 4 = 8\ N$

But

$W_{liquid} = mass\ of\ liquid \times g$

Taking $g = 10\ m/s^2$ it follows that;

$mass\ of\ liquid\ displaced = \frac{W_{liquid}}{g} = \frac{8}{10} = 0.8\ kg$

Now,

$volume\ of\ object = volume\ of\ the\ liquid\ displaced\ = volume\ of\ water\ displaced$

$weight\ of\ water\ displaced = 12 - 2 = 10\ N$

$mass\ of\ water\ displaced = \frac{10}{10} = 1\ kg$

Given the density of water as 1000 kg/m^3 then;

$volume\ of\ water\ displaced = \frac{mass}{density} = \frac{1}{1000} = 0.001\ m^3$

$Hence\ volume\ of\ liquid\ displaced = 0.001\ m^3$

$Density\ of\ liquid = \frac{mass\ of\ liquid\ displaced}{volume\ of\ liquid\ displaced} = \frac{0.8}{0.001}$

$Density\ of\ the\ liquid = 800\ kg/m^3$

(c) Figure 7 shows two identical wooden blocks each of mass 0.2 kg suspended in water by two strings M and N.

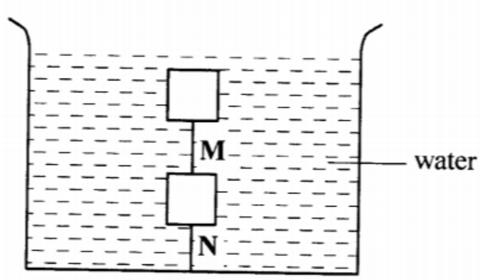
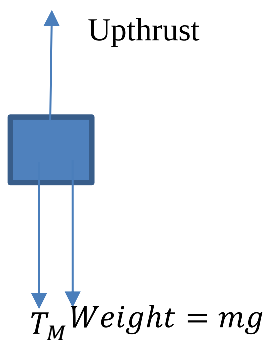


Figure 7

Given that the upthrust on each block is 3.2N, determine the tension in string:

(i) M. (2 marks)

String M is preventing first block from moving up hence tension T_N is acting downwards. Weight of first block is downwards while upthrust is upwards:



Upward forces are equal to downward forces hence;

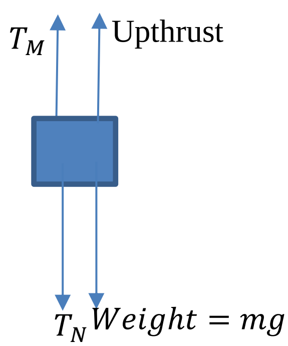
$T_M + mg = upthrust$

$T_N = upthrust - mg$

$T_M = 3.2 - (0.2 \times 10) = 1.2\ N$

(ii) N. (2 marks)

For second block, the tension T_M and upthrust are acting upwards while the tension of the second string T_N and weight are acting downwards.



$Upward\ forces = downward\ forces$

$T_N + mg = T_M + upthrust$

$T_N = (T_M + upthrust) - mg$

$T_N = (1.2 + 3.2) - (0.2 \times 10) = 4.4 - 2$

$T_N = 2.4\ N$

(d) State any one application of hydrometers. (1 mark)

A hydrometer is an instrument for measuring relative density of liquids. A hydrometer when dipped in a denser liquid for example glycerine will displace less liquid (will not go as deep) while when dipped in a less dense liquid (for example paraffin), it will displace more liquid (will go deeper). It can be used to determine the purity of a liquid, for example test the purity of milk given that the density of pure milk is different from the density from that of 'watered' milk.

18. (a) The figure shows a hydraulic brake system

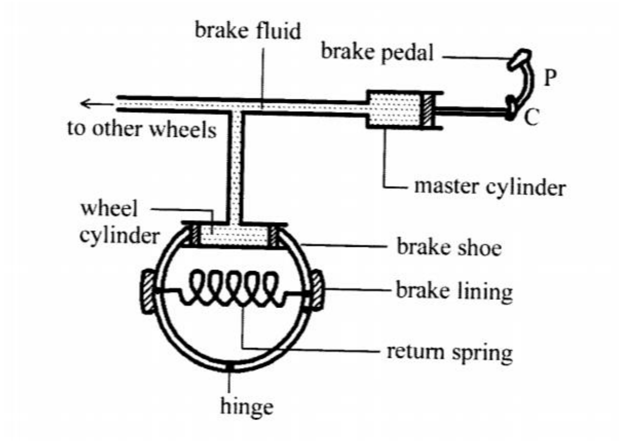


Figure 8

Describe how the systems works (5 marks)

Force applied to liquid in master cylinder generates pressure ($pressure = \frac{force}{area}$) in the master cylinder. This pressure is transmitted uniformly through the fluid to the wheel cylinder. The force generated ($force = pressure \times area$) acts on the brake shoe which in turn presses the brake pads which then stop the wheel from rotating.

(b) State three conditions necessary for a driver to negotiate a bend on a flat level road at a relatively high speed. (3 marks)

- the car tyres should have good treads (should not be smooth) to generate the required friction.
- Wider tyres are also better since they create more friction.
- driver should therefore use outermost lane to increase radius of bend
- Make car lighter

(c) Figure 9 shows two identical cans U and V each with a small opening at the top. Different amounts of water were put into the cans and heated until the water started to boil.

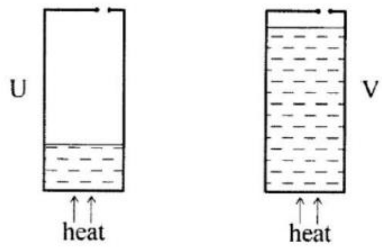


Figure 9

Explain what will be observed when both cans are then suddenly dipped into a cold waterbath. (3 marks)

Steam generated as the water heats up drives out the air in the cans. Since the cans are open, the pressure in the cans equals the atmospheric pressure during the heating process. When the can are suddenly dipped in cold water, the water vapour condenses very fast (turns to water) thus creating partial vacuum. The pressure inside the cans reduces below atmospheric pressure which forces the cans to crash. The deformation is more pronounced in the can with less water as more air was pushed out resulting in a bigger pressure difference.

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