P510/1
PHYSICS
(Theory)
Paper 1
Nov./Dec. 2020
2½ hours

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS

(Theory)

Paper 1

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

Answer **five** *questions, including at least* **one**, *but* **not** *more than* **two** *from each of the sections;* **A**, **B** *and* **C**.

Any additional question(s) answered will **not** *be marked.*

Non-programmable scientific calculators may be used.

Assume where necessary:

Acceleration due to gravity, g	$= 9.81\ ms^{-2}$.
Electron charge, e	$= 1.6 \times 10^{-19}$ C.
Electron mass	$= 9.11 \times 10^{-31}$ kg.
Mass of the earth	$= 5.97 \times 10^{24}$ kg.
Plank's constant, h	$= 6.6 \times 10^{-34}$ Js.
Stefan's Boltzmann's constant, σ	$= 5.67 \times 10^{-8}\ Wm^{-2} K^{-4}$.
Radius of the Earth	$= 6.4 \times 10^{6}$ m.
Radius of the Sun	$= 7 \times 10^{8}$ m.
Radius of earth's orbit about the sun	$= 1.5 \times 10^{11}$m.
Speed of light in a vacuum, c	$= 3.0 \times 10^{8}\ ms^{-1}$.
Thermal conductivity of copper	$= 390\ Wm^{-1} K^{-1}$.
Thermal conductivity of aluminium	$= 210\ Wm^{-1}K^{-1}$.
Specific heat capacity of water	$= 4200\ J\ Kg^{-1} K^{-1}$.
Universal gravitational constant, G	$= 6.67 \times 10^{-11}\ Nm^{2} kg^{-2}$.
Avogadro's number, N_A	$= 6.02 \times 10^{23}\ mol^{-1}$.
Surface tension of water	$= 7.0 \times 10^{-2}\ Nm^{-1}$.
Density of water	$= 1000\ kgm^{-3}$.
Gas constant, R	$= 8.31\ Jmol^{-1}K^{-1}$.
Charge to mass ratio, e/m	$= 1.8 \times 10^{11}\ Ckg^{-1}$.
The constant $\frac{1}{4\pi\varepsilon_0}$	$= 9.0 \times 10^{9}\ F^{-1}m$.
Faraday constant, F	$= 9.65 \times 10^{4}\ Cmol^{-1}$.

SECTION A

1. (a) (i) State the laws of static friction. *(03 marks)*

(ii) Use the molecular theory of matter to explain the laws stated in (a) (i). *(06 marks)*

(b) Describe briefly how to measure the limiting friction between a wooden block and a plane surface. *(04 marks)*

(c) A block of wood of mass 3.95 kg rests on a horizontal table of height 5.0 m at a distance of 6.0 m from the edge of the table. A bullet of mass 50.0 g moving with a horizontal velocity of 500 ms^{-1} hits and gets embedded in the block. If the coefficient of dynamic friction between the block and the table is 0.3;

(i) find the initial velocity of the block after the collision with the bullet. *(02 marks)*

* (ii) calculate the horizontal distance from the table to the point where the block hits the ground. *(05 marks)*

$0.05 + 3.95$

2. (a) Define the following as applied to materials:

(i) Stress. *(01 mark)*

(ii) Young's Modulus. *(01 mark)*

(b) The velocity of compressional waves travelling along a rod made of material of Young's Modulus, E, and density, ρ, is given by $V = \left(\frac{E}{\rho}\right)^{1/2}$.
Show that the formula is dimensionally consistent. *(02 marks)*

(c) Derive an expression for the energy stored in a stretched wire within the elastic limit. *(03 marks)*

(d) A uniform wire of length 2.49 m is attached to two fixed points A and B, a horizontal distance 2 m apart. When a 5 kg mass is attached to the mid-point C of the wire, the equilibrium position of C is 0.75 m below the line AB. Neglecting the weight of the wire and taking Young's Modulus for its material to be 2×10^{11} Nm^{-2}, find the;

(i) strain in the wire. *(04 marks)*

(ii) stress in the wire. *(02 marks)*

(iii) energy stored in the wire. *(04 marks)*

(e) (i) Sketch the stress-strain curve for glass and explain its shape. *(02 marks)*

(ii) Why does glass break easily? *(01 mark)*

3\. (a) (i) Define **centripetal acceleration**. *(01 mark)*

(ii) Show that the force F on a body of mass M moving in a circle of radius r with constant speed V is given by

$$F = \frac{MV^2}{r}.$$ *(05 marks)*

(iii) Derive the condition for a car to move round a banked circular track without slipping. *(04 marks)*

(b) Describe how a helical spring may be used to dertermine the acceleration due to gravity. *(05 marks)*

(c) A particle moving with simple harmonic motion, has a speed of 8.0 ms^{-1} and an acceleration of 12 ms^{-2} when it is 3.0 m from its equilibirum position. Find the;

$a = \omega^2$

(i) amplitude of motion. *(03 marks)*

* (ii) maximum acceleration. *(02 marks)*

4\. (a) Define the following:

(i) Pressure. *(01 mark)*

(ii) Relative density. *(01 mark)*

(b) (i) State Archimedes Principle. *(01 mark)*

(ii) Describe an experiment to determine the relative density of a liquid. *(04 marks)*

(c) (i) Derive the expression for Bernoulli's equation. *(05 marks)*

(ii) Explain why a person standing by the road side may be pulled towards the road when a very fast moving bus passes by. *(03 marks)*

(d) A water tight drum tied to a cable anchored on the sea-bed floats 500 m beneath the sea surface as shown in figure **1**.

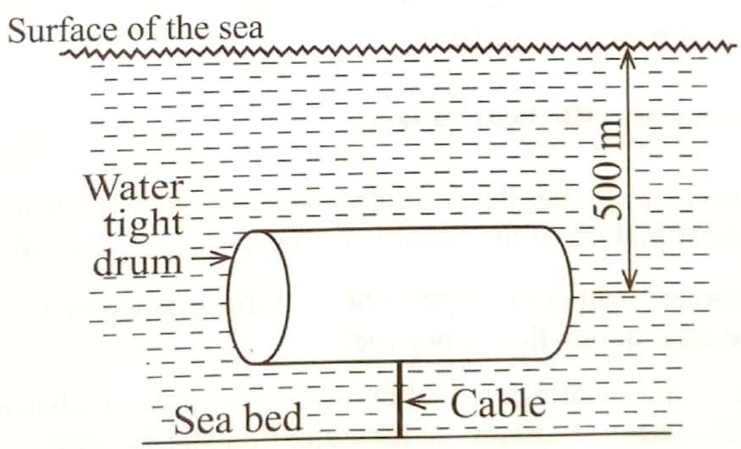


Fig. 1

If the weight of the drum is 500 N and its volume is 25 m^3, calculate the;

(i) pressure on the drum due to the sea water. *(02 marks)*

(ii) tension in the cable assuming it is vertical. *(03 marks)*

SECTION B

5. (a) Define the following:

(i) Tripple point of water. *(01 mark)*

(ii) Absolute zero temperature. *(01 mark)*

(b) Explain why tripple point of water is taken as a standard in modern thermometry instead of ice and steam points. *(04 marks)*

(c) (i) What is a **thermometric property**? *(01 mark)*

(ii) State **three** qualities of a good thermometric property. *(03 marks)*

(d) (i) A constant volume thermometer was used to measure temperature when the atmospheric pressure was 760 mmHg. The following values were obtained.

	Length of Mercury in closed limb (mmHg)	**Length of Mercury in open limb (mmHg**
Bulb in ice	140	130
Bulb in steam	140	330
Bulb at room temperature	140	170

Calculate the room temperature. *(05 marks)*

(ii) List **two** advantages of the constant volume gas thermometer over the mercury in glass thermometer. *(02 marks)*

(e) Explain what happens when the temperature of a fixed mass of ice is raised from 0 °C to 10 °C. *(03 marks)*

6. (a) Define **specific heat capacity**. *(01 mark)*

(b) Describe, stating the assumptions made, an electrical method for the determination of the specific heat capacity of a metal. *(08 marks)*

(c) In an experiment to determine specific heat capacity of a liquid using the continuous flow calorimeter;

(i) the readings are taken when the apparatus has attained a steady state. Explain the meaning of a steady state. *(02 marks)*

(ii) Explain why two sets of readings are taken. *(01 mark)*

(d) When water is passed through a continuous flow calorimeter at the rate of 100 g min^{-1}, the temperature rises from 16 °C to 20 °C, when the p.d across the heater is 20 V and the current is 1.5 A. When another liquid at 16 °C is passed through the calorimeter at the rate of 120 g min^{-1}, the same temperature change is obtained at a p.d of 13 V and current 1.2 A. Calculate the specific heat capacity of the liquid. *(04 marks)*

(e) (i) Define **latent heat**. *(01 mark)*

(ii) Explain why latent heat of vaporisation is always greater than that of fusion. *(03 marks)*

7. (a) (i) Explain how a thermocouple is used to measure temperature on a celsius scale. *(05 marks)*

(ii) State **two** advantages of a thermocouple. *(01 mark)*

(b) (i) Two cylindrical bodies A and B are made of the same material but the length of A is twice that of B and the cross sectional area of B is a third that of A. If the ends of A and B are subjected to the same temperature difference, find the ratio of the rate of heat flow through A to the rate of heat flow through B. *(03 marks)*

(ii) In the determination of thermal conductivity of copper, when water flows round the cool end of a copper rod at a rate of 600 cm^3 per minute, its temperature increases by 3.3 °C. The temperatures at two points, a distance 5.2 cm apart, along the copper rod are 70 °C and 30 °C respectively. Find the thermal conductivity of copper if the radius of the rod is 1.2 cm. *(04 marks)*

(c) Describe an experiment to measure thermal conductivity of cork. *(07 marks)*

SECTION C

8. (a) What is meant by the following as applied to radioactivity?

(i) Activity. *(01 mark)*

(ii) Decay constant. *(01 mark)*

(b) (i) Explain briefly, why radioactivity is referred to as random and spontaneous. *(02 marks)*

(ii) The half life of ${}^{230}_{92}Th$ is 2.4×10^{11} s. Find the number of disintegrations per second that occur in 1 g of ${}^{230}_{92}Th$. *(03 marks)*

(c) (i) Describe, with the aid of a labelled diagram, how the Wilson cloud chamber can be used to detect ionising radiation. *(06 marks)*

(ii) Explain the difference in the patterns of the tracks seen in the chamber when $\alpha-$ and $\beta-$ particles are present in the chamber. *(02 marks)*

(d) (i) What is meant by **mass defect**? *(01 mark)*

(ii) Calculate, in MeV, the energy released when helium nucleons are produced by fusing two neutrons and two protons. *(04 marks)*

Mass of a proton = 1.00759 u.
Mass of a neutron = 1.00898 u.
Mass of helium = 4.00277 u.
1 u = 931 MeV.

9. (a) (i) What is meant by a **p-n junction** as applied to semiconductors? *(01 mark)*

(ii) Explain the term **doping** as appllied to a p-n junction diode. *(03 marks)*

(b) (i) Explain, with the aid of a labelled diagram, the I-V characteristic of a junction diode. *(03 marks)*

(ii) Describe how full wave rectification can be achieved using a bridge rectifier. *(04 marks)*

(c) The input resistance of a certain n-p-n transistor in the common emitter connection is 3 kΩ. The small current amplification transfer ratio is 100. The internal resistance of the emitter-base junction is negligible and the load resistor is 6 kΩ. Find the voltage gain. *(04 marks)*

(d) (i) Explain the mechanism of the thermionic emission. *(03 marks)*

(ii) The gain control of a Cathode Ray Oscilloscope (C.R.O) is set at 0.5 Vcm^{-1}, and an alternating voltage produces a vertical line of length 2.0 cm with the time base off. Find the root mean square value of the potential difference. *(02 marks)*

10. (a) Define **specific charge** of a positive ion and state its unit. *(02 marks)*

(b) With the aid of a labelled diagram, describe how Bainbridge spectrometer can be used to determine the specific charge of positive ions. *(06 marks)*

(c) A beam of positive ions accelerated through a potential difference of 2,000 V enters a region of a uniform magnetic flux density **B**. The ions describe a cricular path of radius 3.2 cm while in the field. If the specific charge of the ions is 8.5×10^7 C kg^{-1}, derive an expression for the charge to mass ratio of the ions and use it to calculate the value of **B**. *(05 marks)*

(d) State the use of each of the following features of Cathode Ray Oscilloscope (C.R.O):

(i) Anode system. *(01 mark)*
(ii) Y-plates. *(01 mark)*
(iii) The grid. *(01 mark)*

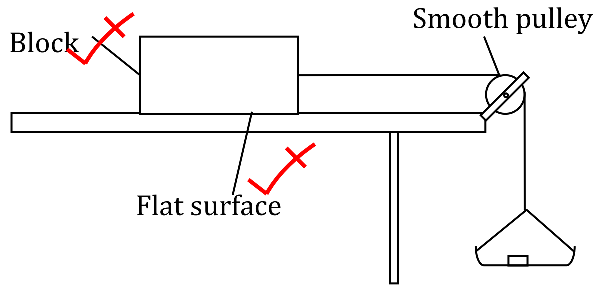
(e) An electron with energy 5 kV moves in the direction of an electric field of intensity $1.6 \times 10^4\ Vm^{-1}$. What distance will the electron move before coming to rest? *(04 marks)*

END

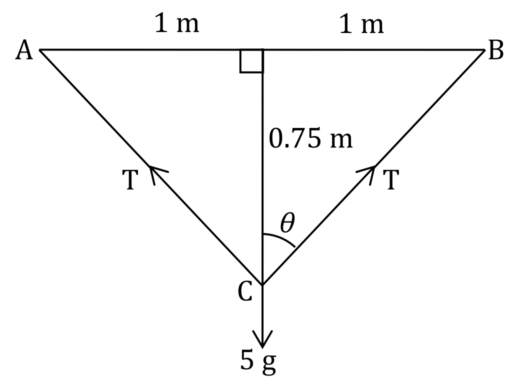
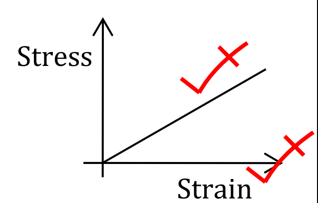
P 510/1 UACE 2020 MARKING GUIDE

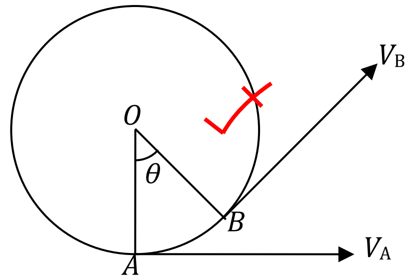
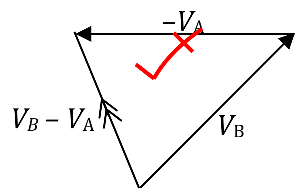
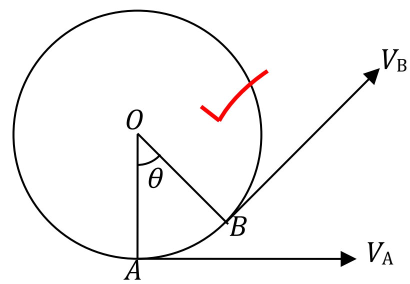
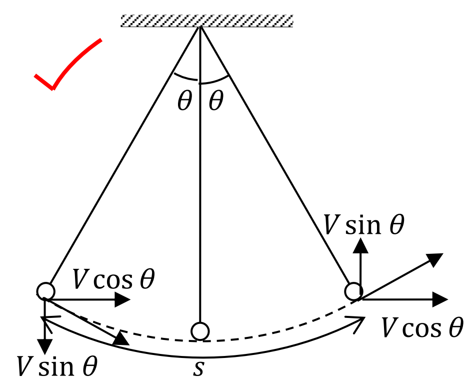
<table>
<tr><th>Qn</th><th>Scoring points</th><th>Mks</th></tr>
<tr><td>1(a)(i)</td><td>Friction opposes attempted relative motion between two surfaces in contact.
– Friction is independent of the area of contact of the surfaces provided the normal reaction is constant.
– The limiting frictional force is proportional to the normal reaction.</td><td>3</td></tr>
<tr><td>(ii)</td><td>– Surfaces in contact rest on each other's molecular projections. The actual area of contact is very small and this leads to very high pressure at these points. These points forms cold welded joints. For the surfaces to move relative to each other, a force must be applied to break the 'welded' joints.
– If normal reaction is kept constant, but the surface are made to rest on a smaller area, fewer points of contact will result. This will cause higher pressure at these points, hence, they tend to flatten out restoring the actual area of contact to the initial value hence, keeping friction constant.
– As the normal reaction increases, the pressure at the welded joints will also increases. This causes the points flatten further/increase in number and the actual are of contact increases, hence increase in in friction.</td><td>2

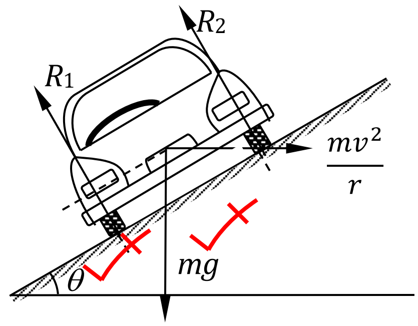
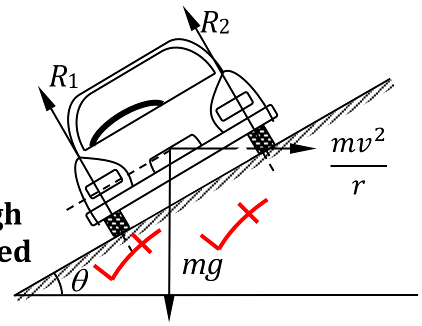
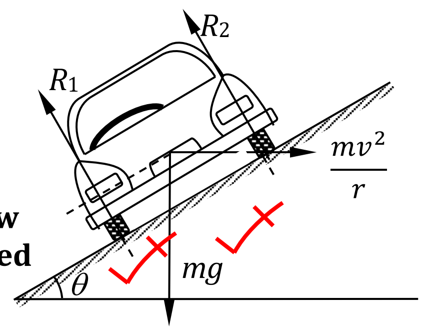
2

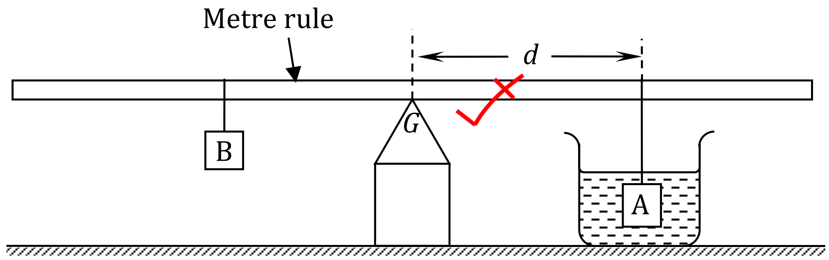
2</td></tr>
<tr><td>(b)</td><td>The mass, M of the block is measured and recorded. The block is placed on a the horizontal plane surface. The horizontal plane surface is gradually tilted until the block just starts to move. The angle θ between the plane and the horizontal ground is measured and recorded. The limiting friction is give as $Mg\sin\theta$.
ALT
– Small masses are added onto the scale pan until the block just start to moves.
– The total mass, m, of the scale pan and its content is measured and recorded.
– Limiting friction is given by, mg.

</td><td>4</td></tr>
<tr><td>(c)(i)</td><td>$M_bU_b = (M_b + M_w)V \Rightarrow 0.05 \times 500 = (3.95 + 0.05)V$; $V = \mathbf{6.24\ ms^{-1}}$</td><td>2</td></tr>
<tr><td>(ii)</td><td>Frictional force, $F = \mu R = 0.3 \times 4 \times 9.81 = 11.772$ N
Deceleration $= \frac{F}{m} = \frac{11.772}{4} = \mathbf{2.942\ ms^{-1}}$
Velocity of the block at the edge of the table; $v^2 = u^2 + 2as$
$v^2 = 6.25^2 + 2(-2.942) \times 6 = 3.7465$
$v = \mathbf{1.936\ ms^{-1}}$
Time to hit the grounds ; $s = ut + \frac{1}{2}at^2$
$5 = \frac{1}{2} \times 9.81t^2 \quad \therefore \quad t = \sqrt{\frac{10}{9.81}} = \mathbf{1.01\ s}$
Horizontal distance covered= vt = 0,01 × 1.9636 = 1.96 m
ALT (Work – energy theorem) $Fs = \frac{1}{2}m(v^2 - u^2)$; $11.77 \times 6 = \frac{1}{2} \times 4(6.25^2 - u^2)$ $u = \mathbf{1.936\ ms^{-1}}$</td><td>5

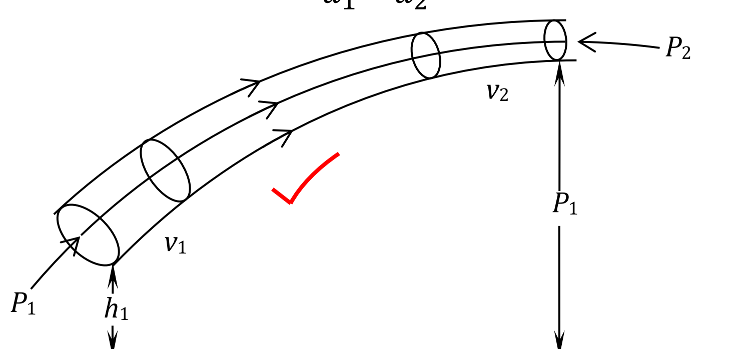
20</td></tr>
</table>

Qn	Scoring points	Mks
2(a)(i)	Stress is force per unit cross – sectional area.	1
(ii)	Young's modulus is the ratio of tensile stress to tensile strain.	1
(b)	$V = \left(\frac{E}{\rho}\right)^{\frac{1}{2}}$; $[V] = LT^{-1}$; $\left(\frac{ML^{-1}T^{-2}}{ML^{-3}}\right)^{\frac{1}{2}} = LT^{-1}$ LHS = RHS hence, consistent	2
(c)	Average force $= \frac{0+F}{2} = \frac{1}{2}F$; Work fone $= \frac{1}{2}Fx$ But $F = kx$ ∴ $W = \frac{1}{2}Fx^2$ ALT W $= \int_0^x F.dx$; $F = kx$ ∴ $W = \int_0^x kx.dx = \frac{1}{2}kx^2$	2
(d)(i)	$BC^2 = 0.75^2 + 1^2$ ∴ BC = 1.25 m New length = AB + BC = 2.50 m Extension, e = 2.50 – 2.49 = 0.01 m Strain $= \frac{e}{l} = \frac{0.01}{2.49} = \mathbf{0.004016}$ 	4
(ii)	Young's modullus $= \frac{\text{Stress}}{\text{Strain}}$; Stress $= 2.0 \times 10^{11} \times 0.004016$ $= \mathbf{8.03 \times 10^8\ Pa}$	2
(iii)	$2T\cos\theta = 5$ g; $\cos\theta = \frac{0.75}{1.25}$ $T = \frac{5 \times 9.81 \times 1.25}{2 \times 0.75} = \mathbf{40.88\ N}$ Energy stored $= \frac{1}{2}Fe = \frac{1}{2} \times 40.88 \times 0.001 = 0.204$ J	4
(e)	Glass is brittle and only suffer eleastic deformation. (or does not undergo plastic deformation) The surface of glass has a crack in it. A high concentration of stress on the crack makes it to kreak. 	3
		20

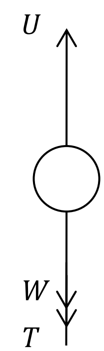
Qn	Scoring points	Mks
3(a)(i)	Acceleration is the rate of change of velocity for a body moving in a circular path.	1
(ii)	Consider a body of mass, *m*, moving in a circle of radius, *r*, with a constant speed, *v*.	1
	$a = \frac{\text{Change in velocity}}{\text{time taken}}$ $a = \frac{V_B - V_A}{\delta t}$ From the diagram,dor a small angle, $\delta\theta$, we have $V_B - V_A = V\,\delta\theta$, Since $\lvert V_A \rvert = \lvert V_B \rvert = v$ $\therefore\ a = v\frac{\delta\theta}{\delta t} = v\omega$, But $\omega = \frac{v}{r}$ $\Rightarrow a = v.\frac{v}{r} = \frac{v^2}{r}$ Now $F = ma$ $\therefore$ $F = \frac{mv^2}{r}$  	5
	ALT $a_x \lim_{\delta t \to 0} \frac{V\cos\delta\theta - V}{\delta t} = \lim_{\delta t \to 0} \frac{V\cos\delta\theta - V}{\delta t}$ As $\delta\theta \to 0$; $(\cos\theta - 1) \to 0$ $\therefore\ a_x = 0$ $a_y \lim_{\delta t \to 0} \frac{V\sin\delta\theta - 0}{\delta t}$ As $\delta\theta \to 0$; $\sin\delta\theta \to \delta\theta$ $a = v\frac{\delta\theta}{\delta t} \Rightarrow a = v\omega$ for small angle in radians But $v = \omega r$ $\therefore$ $a = \frac{v^2}{r}$, $F = ma$ $\therefore$ $F = \frac{mv^2}{r}$ 	5
	ALT $a_x = \frac{V\cos\theta}{t} - V\cos\theta = 0$ $a_y = \frac{V\sin\theta}{t} - -V\sin\theta = \frac{2V\sin\theta}{t}$ But $t = \frac{2r\theta}{V}$ $\therefore\ a_y = \frac{V^2}{r} \cdot \frac{\sin\theta}{\theta}$, But $\frac{\sin\theta}{\theta} = 1$ for small θ in radians $a = \frac{V^2}{r}$; $F = ma$ $\therefore$ $F = \frac{mV^2}{r}$ 	5

Qn	Scoring points	Mks
(iii)	Consider a car of mass, m, moving with a speed, v, round a circular track of radius , r, banked an angle, θ. $\therefore \quad (R_1 + R_2)\sin\theta = \dfrac{mv^2}{r}$ ... ... 1 $(R_1 + R_2)\cos\theta = mg$ ... ... 2 $\therefore \quad \tan\theta = \dfrac{v^2}{rg}$ Or $v = (rg\tan\theta)^{\frac{1}{2}}$ And for slipping not to occur, $v < (rg\tan\theta)^{\frac{1}{2}}$ 	4
	ALT 1 $R\sin\theta + \mu R\cos\theta = \dfrac{mv^2}{r}$ $R\cos\theta - \mu R\sin\theta = mg$ $v_{max} = \left[\dfrac{rg(\tan\theta + \mu)}{1 - \mu\tan\theta}\right]^{\frac{1}{2}}$ **High speed** 	4
	ALT 2 $R\sin\theta - \mu R\cos\theta = \dfrac{mv^2}{r}$ $R\cos\theta + \mu R\sin\theta = mg$ $v_{min} = \left[\dfrac{rg(\tan\theta - \mu)}{1 + \mu\tan\theta}\right]^{\frac{1}{2}}$ **Low speed** 	4
(b)	Not in the guide	5
(c)(i)		3
(ii)		2
		20

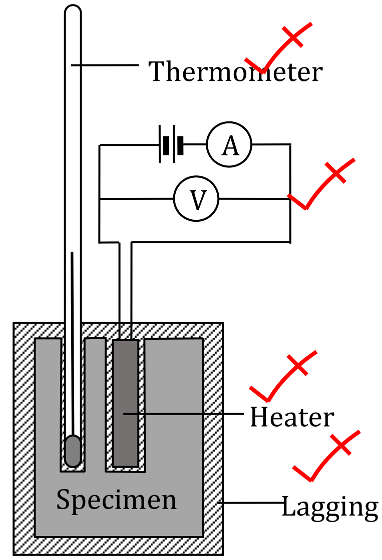
<table>
<tr><th>Qn</th><th>Scoring points</th><th>Mks</th></tr>
<tr><td>4(a)(i)</td><td>Pressure is the force acting normally per square metre area.</td><td>1</td></tr>
<tr><td>(ii)</td><td>Relative density is the ratio of mass of a substance to the mass of an equal volume of water.</td><td>1</td></tr>
<tr><td>(b)(i)</td><td>Archimedes' principle states that when a body is wholly or partially immersed in a fluid, it experiences an up-thrust equal to the weight of the fluid displaced.</td><td>1</td></tr>
<tr><td>(ii)</td><td>
– An object is weighed in air using a spring balance and its weight, W_1 is noted.
– The object is fully immersed in water and the new reading of the spring balance is notted, W_2. Up-thrust in water, $U_1 = W_1 - W_2$ is calculated.
– The object is then immersed in a liquid whose relative density is required. New reading, W_3 is notted. Up-thrust in the liquid, $U_2 = W_1 - W_3$.
– Relative density $= \dfrac{\text{Up-thrust in liquid}}{\text{Up-thrust in water}} = \dfrac{U_2}{U_1} = \dfrac{W_1 - W_3}{W_1 - W_2}$
</td><td>4</td></tr>
<tr><td></td><td>
ALT
– A metre rule is balanced on a knife edge; the balance point, G is noted (marked on the metre rule).


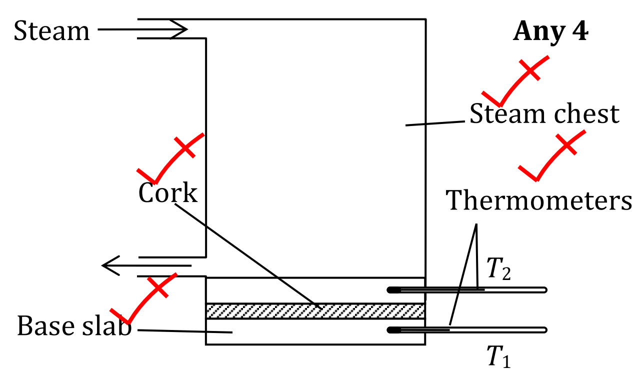
– A sinker, A, is hung at a distance, d from G.
– A standard mass, B, is hung from the opposite side and its position is adjusted until the metre rule balances horizontally, keep G above the knife edge and d constant.
– Distance, d_1 of B from G is noted.
– The procedure is repeated with A in water and distance d_2 of B from G is noted.
– Procedure is repeated with A in liquid under test and distance d_3 of B from G is noted.
– Relative density of the liquid is obtained from, R.D $= \dfrac{d_1 - d_3}{d_1 - d_2}$
</td><td>4</td></tr>
<tr><td>(c)(i)</td><td>
Work done per unit Volume $= \dfrac{F \times \text{distance}}{\text{Volume}} = \dfrac{PAd}{V} = P$


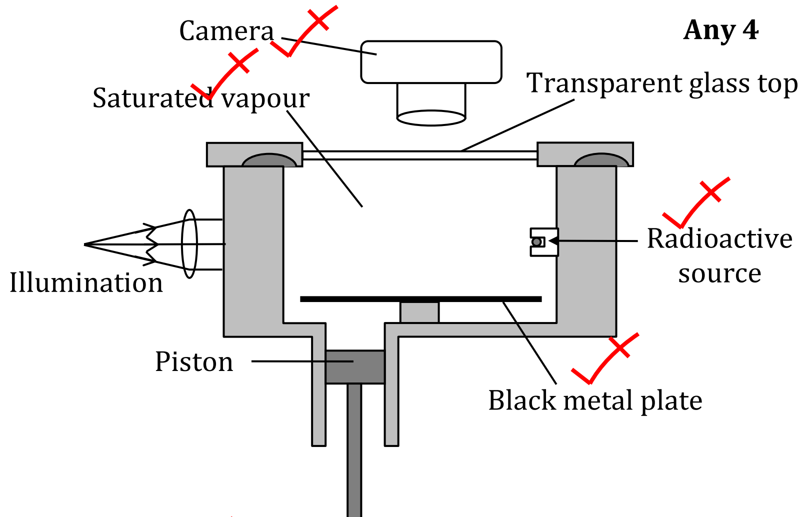
$\dfrac{k.e}{V} = \dfrac{1}{2}\dfrac{mv^2}{V} = \dfrac{1}{2}\dfrac{\rho v^2}{V}$; $\dfrac{p.e}{V} = \dfrac{mgh}{V} = h\rho g$
Work done by pressure difference $= \dfrac{\text{Gain in } k.e}{\text{Volume}} + \dfrac{\text{Gain in } p.e}{\text{Volume}}$
$P_1 - P_2 = \left(\dfrac{1}{2}\rho v_2^{\,2} - \dfrac{1}{2}\rho v_1^{\,2}\right) + (h_2\rho g - h_1\rho g)$
$P_1 + \dfrac{1}{2}\rho v_1^{\,2} + h_1\rho g = P_2 + \dfrac{1}{2}\rho v_2^{\,2} + h_2\rho g$
$\therefore\ P + \dfrac{1}{2}\rho v^2 + h\rho g = \text{A constant}$
</td><td>5</td></tr>
</table>

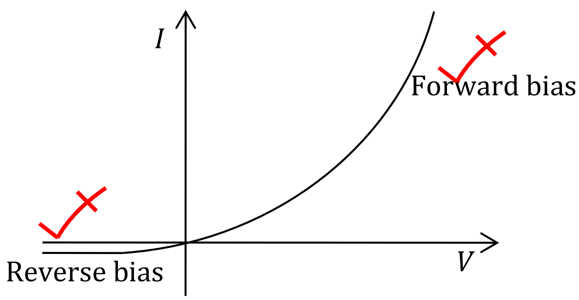
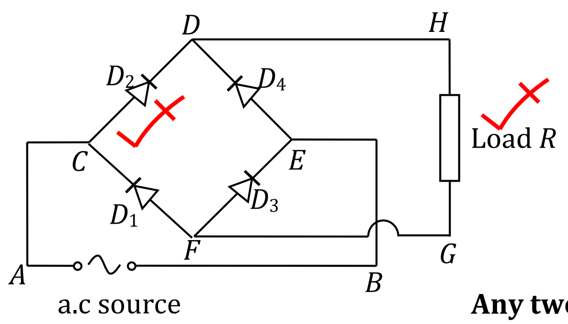
Qn	Scoring points	Mks
	ALT Diagram $P_1A_1v_1 - P_2A_2v_2 = \frac{1}{2}\rho A_2V_2^{\ 3} - \frac{1}{2}\rho A_1V_1^{\ 3} + A_2v_2\rho gh_2 - A_1v_1\rho gh_1$ But $A_1V_1 = A_2V_2$ $\therefore\ P_1 - P_2 = \left(\frac{1}{2}\rho v_2^{\ 2} - \frac{1}{2}\rho v_1^{\ 2}\right) + (h_2\rho g - h_1\rho g)$ $P_1 + \frac{1}{2}\rho v_1^{\ 2} + h_1\rho g = P_2 + \frac{1}{2}\rho v_2^{\ 2} + h_2\rho g$ $\therefore\ P + \frac{1}{2}\rho v^2 + h\rho g$ = A constant	5
(ii)	– As a bus passes, it makes the air between the man and bus to move with a high velocity. – The air behind the man has a low velocity. – By Bernoulli's principle, there is low pressure between the man and bus and high pressure behind the man. – The pressure difference causes a net force that pushes the man towards the bus.	3
(d)(i)	P $= h\rho g = 500 \times 10^3 \times 9.81$ $=$ **4.91×10^6 Nm^{-2}**	2
(ii)	Upthrust = Weight of water displaced $= V\rho g = 25 \times 10^3 \times 9.81$ $=$ **245,250** In Equilibrium $U = W + T$ $245{,}250 = 500 + T$ $\therefore$ T $=$ **2.45×10^5 N** 	3
		20

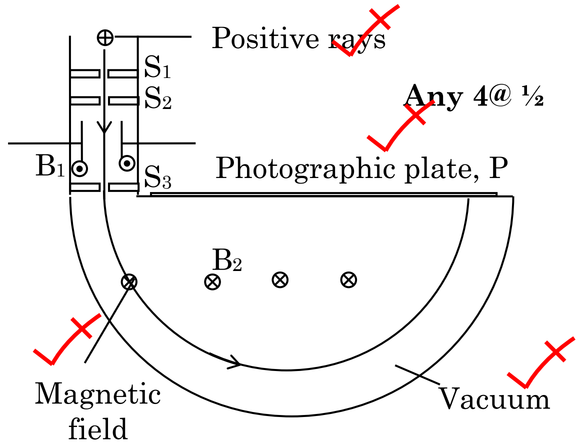
Qn	Scoring points	Mks
5(a)(i)	Tripple point of water is the temperature at which pure water, pure water vapour and pure ice are in equilibrium.	1
(ii)	Absolute zero is the temperature at which the k.e of the molecules of substance has the least possible value.	1
(b)	Tripple point is a <u>single temperature</u> and a <u>single pressure</u>. Ice and steam points vary with pressure and level of impurity.	4
(c)(i)	– A physical roperty of a substance that vary lineaely and continously with temperature.	1
(ii)	– Should vary lineaely and continously with temperature. – It should give a single value for a certain temperature. – Vary oveer a wide temperature range. – Accurately be measurable over a wide range of temperatures for a simple apparatus. **Any three**	3
(d)(i)	$h_o = (130 - 140) = -10$, $h_\theta = (170 - 140) = 30$, $h_{100} = (330 - 140) = 190$ $\theta = \left(\frac{h_\theta - h_o}{h_{100} - h_o}\right) \times 100\ ^oC$, $= \left(\frac{130 - {}^-10}{190 - 10}\right) \times 100\ ^oC$, $= 20\ ^oC$,	5
(ii)	Accurate, sensitive, wide range **Any 2**	2
(e)	At 0 ^oC, the bond between the ice molecules are **weakened** and ice **melts**. Between 0 ^oC and 4 ^oC water **contracts**. Beyond this temperature water expands	3
		20

Qn	Scoring points	Mks
6(a)(i)	Specific heat capacity is the quantity of heat required to raise the temperature of 1 kg mass of asubstance by 1 K or 1 ^{o}C.	1
(b)	– Two holes are drillde into the solid and the **mass**, *m* of the solid is measured and recorded. – The initial temperature, θ_1 of the block is recorded. – The switch is closed and the stop clock started simultaneously. – The ammeter and voltmeter readings of *I* and *V* respectively are recorded. – When the temperature has risen by about 10 K, the heater is switched off and the stop clock stopped and the **time**, *t* is notted. – The highest temperature, θ_2 is recorded. – The specific heat capacity, c is obtained from $c = \frac{IVt}{m(\theta_1 - \theta_0)}$ 	6
	Assumptions – Heat loss to the surrounding is negiligible – Thermometer and heater takes negiligible amount of heat. – Block has a constant volume	2
(c)(i)	– It should be in a condition during which heat its temperature. It's used to maintain its temperature (condition in which inflow temperature and outflow temperature are constant) – Heat is lost to the surrounding at a constant rate.(Electric power supplied = power absorbed by the liquid + power lost to the surrounding)	2
(ii)	Two sets of readings are obtained to account for heat loses to the surrounding during steady state.	1
	For water $I_1V_1 = m_1c_w(\theta_2 - \theta_1) + h$ $1.5 \times 20 = \frac{0.1}{60} \times 4200 \times 4 + h \quad \Rightarrow \quad h = 2\ \text{Js}^{-1}$ For liquid $I_2V_2 = m_2c_l(\theta_2 - \theta_1) + h$ $1.2 \times 13 = \frac{0.12}{60} \times c_l \times 4 + 2 \quad \Rightarrow \quad c_l = 1700\ \text{Jkg}^{-1}\text{K}^{-1}$	4
(d)	Latent heat is the heat required to change the state of a substance to another state at the same temperature.	1
	In vaporisation, heat is required to break the intermolecular attraction between the molecules of the liquid in the surface and bulk of the liquid and for the vapour to **expand** and do **work** against atmospheric pressure whereas in fussion, heat is only needed to weaken intermolecular attraction.	3 **20**

Qn	Scoring points	Mks
7(a)(i)	– The hot junction of a thermopile is placed in pure melting ice, the e.m.f E_o is noted. – It is then placed in steam and then in contact with the body of unknown temperature, θ. – The e.m.fs E_{100} and E_θ are noted respectively. – The unknown temperature is obtained from $\theta = \frac{E_\theta - E_o}{E_{100} - E_o} \times 100\ ^oC$ – Also accept $\theta = \frac{E_\theta}{E_{100}} \times 100\ ^oC$ when $E_\theta = 0$	5
(ii)	– Can measur temperature at a point – It is very sensitive to temperature changes. – It is portable – It has a wide range of temperature **Any two**	2
(b)(i)	$l_A = 2l_B \Rightarrow l_B = \frac{l_B}{2}$; $A_A = A$; $A_B = \frac{A}{B}$ $\frac{\theta}{t} = kA\frac{\Delta T}{l}$ $\left(\frac{\theta}{t}\right)_A = \frac{kA\Delta T}{l_A}$; $\left(\frac{\theta}{t}\right)_B = \frac{k\frac{A}{B}\Delta T}{\frac{1}{2}l_A}$ $\left(\frac{\theta}{t}\right)_B = \frac{2kA\Delta T}{3l_A}$; $\frac{\left(\frac{\theta}{t}\right)_A}{\left(\frac{\theta}{t}\right)_B} = \frac{kA\Delta T}{l_A} \times \frac{3l_A}{2kA\Delta T} = \frac{3}{2}$ Ratio = 3:2 Or 1:1.5	3
(ii)	Mass, $m = V\rho = 600 \times 1 = 600$ g; $\frac{m}{t} = \frac{600}{1000 \times 60} = 0.01\ kgs^{-1}$ $A = 3.14 \times 0.012^2$ Rate of heat transfer through metal = Rate of heat absorption by water $\frac{kA(\theta_2 - \theta_1)}{l} = \frac{m}{t} c\Delta t$ $\frac{k(3.14 \times .012^2)(70 - 30)}{5.2 \times 10^{-2}} = 0.01 \times 4200 \times 3.3$ $k = \mathbf{398.5\ Wm^{-1}K^{-1}}$	4
(c)	The cork is made into a thin wide disc and its diameter, d, and thickness, l, are measured and recorded. The disc is then put between the brass disc slab and steam chest. The cock and brass surfaces are the smeared with Vaseline for better thermal contact. Steam is passed through the steam chest until thermometers T_1 and T_2 shows steady values. The temperatures and θ_2 are recorded. The specimen is removed and the brass slab heated directly to a higher temperature than , θ_1. The specimen is replaced and temperature of the slab is recorded at regular time intervals. A cooling curve is plotted. The slope, S, of the curve at θ_1 is obtained.  **Any 4** $\Rightarrow \frac{kA(\theta_2 - \theta_1)}{l} = mcS$; $k = \frac{4lmcS}{\pi d^2(\theta_2 - \theta_1)}$ where m = mass of slab, c = s.h.c of brass slab, A = πd^2	5 **20**

Qn	Scoring points	Mks
8(a)(i)	Activity is the number of disintegrations per second of a radioactive sample.	1
(ii)	Decay constant is the fractional/ number of disintgration per second of a radioactive sample.	1
(b)	Radioactive decay process is random because no one can tell which nucleus is going to disintegrate next and spontaneous because the rate of disintegration can not be controlled (speeded up or slowered down) by any physical or chemical change	2
	Number of disintegration per second $A = \lambda N$ But $\lambda = \frac{0.693}{t_{1/2}} = \left(\frac{0.693}{2.4 \times 10^{11}}\right) s^{-1}$ Since 230 g of Th contain 6.03×10^{23} atoms Then 1 g of Th contain $\frac{6.02 \times 10^{23}}{230}$ atoms $\Rightarrow A = \left(\frac{0.693}{2.4 \times 10^{11}}\right) \times \frac{6.02 \times 10^{23}}{230}$ $=$ $\mathbf{7.55 \times 10^{9}\ s^{-1}}$	3
(c)(i)	With alcohol on the dark pad, the piston is moved down quickly so as to expand the air in the chamber adiabatically and cools. After a few expansions, the dust particles are all carried away and the dust free air is subjected to controlled adiabatic expansions. The air becomes supersaturated and simultaneously, the air is exposed to radiation from a radioactive source. Water droplets immediately collect around the ions produced. The droplets are then illuminated and photographed by the camera. **Any 4**  	6
(ii)	α – particles, thick short and straight tracks compared to the thin longer and tortuous tracks produced by β – particles because α – particles are more massive and slower compared to β – particles which are less massive and therefore easily deflected after collision with gas molecules.	2
(d)(i)	Mass defect is the difference between the mass of the nucleons and the mass of the nucleus of an atom	
(ii)	$2{}_{0}^{1}n + 2{}_{1}^{1}H \longrightarrow {}_{2}^{4}He + \text{Energy}$ $2(1.00898u) + 2(1.00759u) = 4.0027u$ Energy $= 0.03037u$ $= 0.03037 \times 931$ $=$ **28. 27447 MeV**	4 **20**

Qn	Scoring points	Mks
9(a)(i)	A p – n junction is one formed by melting the boundaries of a p – type and n – type semiconductors and joining them.	1
(ii)	Dopping is the introduction of controlled amount of group V impurities into one half of group IV semiconductors and group III impurities into the other half of group IV semiconductors. The first half has electrons as the majority charge carriers and therefore called n – type while the second half has “holes” as the majority charge carriers forming the p – type.	3
(b)(i)	 When the p – n junction is connected in the forward bias, there is a large flow of electrons and hence high current. In the reverse bias, there is a small current ue to maniority charge carriers flow.	3
(ii)	 **Any two** During the half cycle when A is positive relative to B, diodes D_2 annd D_3 are forward bias and conduct and current flows through the load in the direction H to G. Diodes D_1 and D_4 are reverse bias and do not conduct. During the half cycle when B is positive relative to A, diodes D_1 annd D_4 are forward bias and conduct and current flows through the load in the direction H to G. Diodes D_2 and D_3 are reverse bias and do not conduct.	4
(c)	Voltage gain, μ $= \dfrac{\Delta V_o}{\Delta V_i} = \beta \dfrac{R_L}{R_i + R_s}$ $= \dfrac{6 \times 10^3}{3 \times 10^3 + 0} \times 100$ $= 200$	4
(d)(i)	Metals contain free electrons. When a metal is heated to a high temperature, electrons gain k.e. Those electrons whose energy is sufficient to overcome the attractive force of the positive nuclei leaves the surface of the metal implying thermionic emission.	3
(ii)	$V_o = \dfrac{0.5 \times 2}{2} = 0.5$ V $V_{r.m.s} = \dfrac{V_o}{\sqrt{2}} = \dfrac{0.5}{\sqrt{2}} = 0.354$ V	2
		20

Qn	Scoring points	Mks
10(a))	Specific charge of an ion is the ratio of charge of the ion to the mass of the ion. Its S.I unit are Ckg^{-1}	2
(b)	Positive ions enter the chamber through slit S_1 and S_2. They are then acted on by crossed magnetic and electric fields of flux density, B_1 ns intensity E.  **Any 4@ ½** $EQ = B_1Qv \Rightarrow v = \frac{E}{B}$ where Q is the charge on the ion and v their velocity. Only ions with velocity $v = \frac{E}{B}$ pass through the velocity selector undeflected and enter the momentum selector where magnetic field of flux density B_2 is applied. They describe a circular path of radius, R and strike the photographic plate. $B_2Qv = \frac{mv^2}{R}$ where m is the mass of the ion $\frac{Q}{m} = \frac{v}{B_2R} \Rightarrow \frac{Q}{m} = \frac{E}{B_1B_2R}$	6
(c)	$VQ = \frac{1}{2}mu^2 \Rightarrow \frac{Q}{m} = \frac{1}{2}\frac{u^2}{V}$ $BQu = \frac{mu^2}{r}, \quad u^2 = \frac{Q^2B^2r^2}{m^2}$ $\frac{Q}{m} = \frac{1}{2}\frac{Q^2B^2r^2}{m^2V} \quad \therefore \frac{Q}{m} = \frac{2V}{B^2r^2}$ $8.5 \times 10^7 = \frac{2 \times 2000}{B^2 \times 0.032^2} \Rightarrow B$ **= 0.214 T**	5
(d)(i) (ii) (iii)	– Anode system accelerates and focuses electron. – Y – plates deflects the electrons vertically. – Grid controls the number of electrons striking the screen per second, hence controls the brightness	3
(e)	$\frac{1}{2}mu^2 = 5 \times 10^3 \times 1.6 \times 10^{-19}$ $u^2 = \frac{2 \times 5 \times 10^3 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}} = 2 \times 7.82 \times 10^{14}$ $a = \frac{-Ee}{m} = \frac{1.6 \times 10^4 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}} = -2.810 \times 10^{15}$ $v^2 = u^2 + 2as \Rightarrow 0 = 2 \times 7.82 \times 10^{14} - 2 \times 2.810 \times 10^{15} \times s$ s **= 0.3125 m**	4
	Other alternative may involve 5×10^3 J as energy or 5 eV as energy.	**20**