N17/4/PHYSI/SP2/ENG/TZ0/XX

Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

Tuesday 31 October 2017 (afternoon)

1 hour 15 minutes

Candidate session number

17	N	[Z	0	P	2	P	M	S	L

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

$\frac{42}{50} = 84\%$.

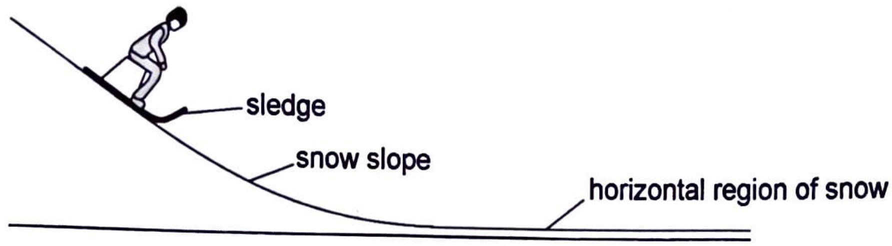
29/9/22

11 pages

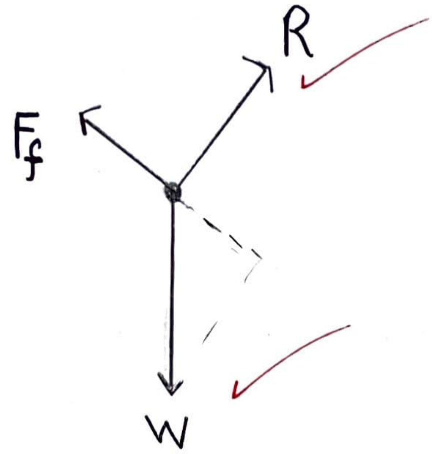
8817–6505

Answer **all** questions. Answers must be written within the answer boxes provided.

1. A girl on a sledge is moving down a snow slope at a uniform speed.



(a) Draw the free-body diagram for the sledge at the position shown on the snow slope. [2]



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(b) After leaving the snow slope, the girl on the sledge moves over a horizontal region of snow. Explain, with reference to the physical origin of the forces, why the vertical forces on the girl must be in equilibrium as she moves over the horizontal region. [3]

- Weight (W) is the only force vertically experienced downward
- Horizontal surface will offer an equal and opposite normal force, hence making the NET vertical force = 0
- When $(F_{net})_v = 0$, vertical equilibrium.

3

(This question continues on the following page)

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(Question 1 continued)

(c) When the sledge is moving on the horizontal region of the snow, the girl jumps off the sledge. The girl has no horizontal velocity after the jump. The velocity of the sledge immediately after the girl jumps off is $4.2\ \text{m s}^{-1}$. The mass of the girl is 55 kg and the mass of the sledge is 5.5 kg. Calculate the speed of the sledge immediately before the girl jumps from it. [2]

Conservation of momentum: $u(m_g + m_s) = V_g m_g + V_s m_s$

$\Rightarrow u = \dfrac{4.2 \times 5.5}{55 + 5.5}$

$= 0.382\ \text{ms}^{-1}$

2

(d) The girl chooses to jump so that she lands on loosely-packed snow rather than frozen ice. Outline why she chooses to land on the snow. [3]

- impulse when landing will be longer due to $\Delta t \Rightarrow$ impulse $= F\Delta t$ $\Rightarrow$ impulse stays same
- this way, the change in kinetic energy E_k will be spread over a longer period of time
- hence, the ~~jump~~ impact, at any given time, will place less force on the girl, reducing chance of injury

1

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3/

Turn over

(Question 1 continued)

(e) The sledge, without the girl on it, now travels up a snow slope that makes an angle of 6.5° to the horizontal. At the start of the slope, the speed of the sledge is 4.2 m s^{-1}. The coefficient of dynamic friction of the sledge on the snow is 0.11.

(i) Show that the acceleration of the sledge is about -2 m s^{-2}. [3]

$F_{net} = (W_{\parallel} + F_f) = (W_{\parallel} + \mu_d W_{\perp}) = ma$

$\Rightarrow a = \dfrac{5.5\times9.81\times\sin6.5 + 0.11\times5.5\times9.81\times\cos6.5}{5.5}$

$= \cancel{2.183}\ -2.182687\ \text{ms}^{-2}$

$\approx -2.18\ \text{ms}^{-2}$

$\approx -2\ \text{ms}^{-2}$

3

(ii) Calculate the distance along the slope at which the sledge stops moving. Assume that the coefficient of dynamic friction is constant. [2]

DATA

$u = 4.2\ \text{ms}^{-1}$

$a = -2.18\ \text{ms}^{-2}$

$v = 0\ \text{ms}^{-1}$

$s = ?$

$v^2 = u^2 + 2as \Rightarrow s = (v^2 - u^2)/2a$

$= -4.2^2/2\,(\cancel{\text{measure}})(-2.18)$

$= 4.0459\ \text{m}$

$\approx 4.0\ \text{m}$

2

(f) The coefficient of static friction between the sledge and the snow is 0.14. Outline, with a calculation, the subsequent motion of the sledge. [2]

$\rightarrow F_f \leq 0.14\times5.5\times9.81\times\cos6.5 = 7.50514\ \text{N}$

$\rightarrow W_{\parallel} = 9.81\times5.5\times\sin6.5 = 6.10788\ \text{N}$

AS $W_{\parallel} < F_f$, the sledge will remain stationary

2

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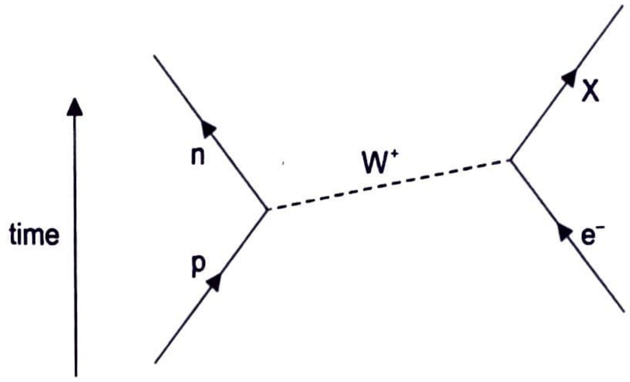
2. The Feynman diagram shows electron capture.



(a) Deduce that X must be an electron neutrino. [2]

~~Conservation~~ $\lfloor p + e^- \rightarrow n + X \rfloor$

=> conservation of lepton number : 0+1 → 0 + 1 {must be lepton}

=> conservation of charge : +1 + (−1) → 0 + 0 {no charge}

A [Lepton] with [no charge] = electron neutrino

2

(b) Distinguish between hadrons and leptons. [2]

- Hadrons : made of quarks (either baryon or meson)
- Leptons : fundamental ~~at par atom~~ particles, do not exist in quarks : electron, muon, tau

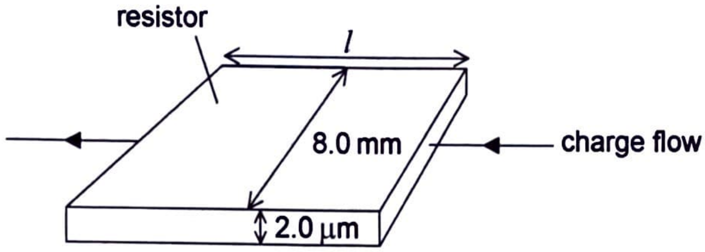
2

4

Turn over

3. Electrical resistors can be made by forming a thin film of carbon on a layer of an insulating material.

(a) A carbon film resistor is made from a film of width 8.0 mm and of thickness 2.0 μm. The diagram shows the direction of charge flow through the resistor.



not to scale

(i) The resistance of the carbon film is 82 Ω. The resistivity of carbon is $4.1 \times 10^{-5}\,\Omega\,m$. Calculate the length l of the film. **[1]**

DATA

$A = 2\times10^{-6} \times 8\times10^{-3} = 1.6\times10^{-8}\ m^2$

$\rho = 4.1\times10^{-5}\ \Omega\ m$

$R = 82\ \Omega$

$l = ?$

$l = RA/\rho$

$= \frac{82 \times 1.6\times10^{-8}}{4.1\times10^{-5}}$

$\therefore l = 0.082\ m$ ✓

1

(ii) The film must dissipate a power less than 1500 W from each square metre of its surface to avoid damage. Calculate the maximum allowable current for the resistor. **[2]**

$P = I^2R \rightarrow I = \sqrt{\frac{1500}{82}} = 4.28\ A.$

power =

1

(iii) State why knowledge of quantities such as resistivity is useful to scientists. **[1]**

• Scientists can differentiate between types of materials such as insulators or conductors for particular ~~scenarios~~ ~~senarios~~ situations ✓

1

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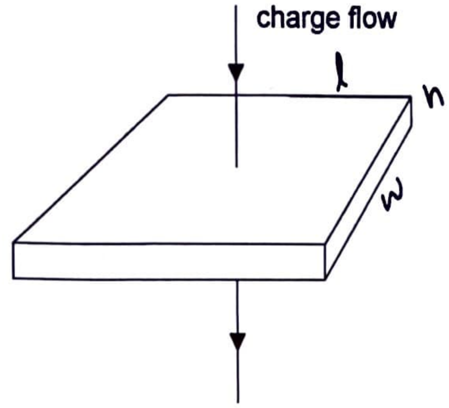
(Question 3 continued)

(b) The current direction is now changed so that charge flows vertically through the film.



not to scale

Deduce, without calculation, the change in the resistance. [2]

without calculation is qualitative

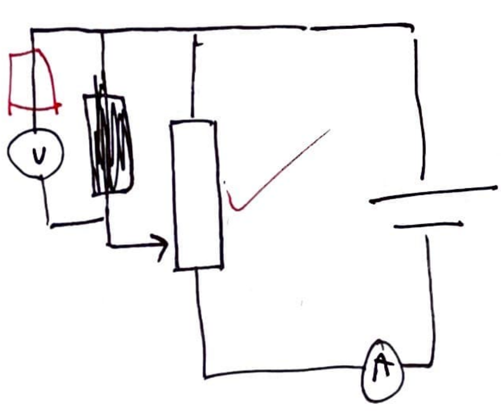
$\Delta R = \frac{l\rho}{hw} - \frac{h\rho}{lw} = \frac{\rho}{w}\left(\frac{l^2-h^2}{hl}\right)$ ×

Area larger, length much smaller.

∴ resistance is smaller.

1

(c) Draw a circuit diagram to show how you could measure the resistance of the carbon-film resistor using a potential divider arrangement to limit the potential difference across the resistor. [2]



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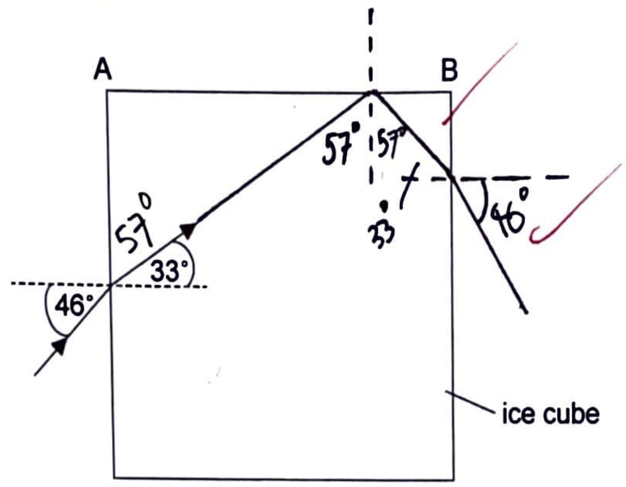
4. (a) A large cube is formed from ice. A light ray is incident from a vacuum at an angle of 46° to the normal on one surface of the cube. The light ray is parallel to the plane of one of the sides of the cube. The angle of refraction inside the cube is 33°.



$n_1 = 1$
$n_2 = ?$
$\theta_1 = 46$
$\theta_2 = 33$
$v_1 = 3\times10^8$
$v_2 = ?$

2

(i) Calculate the speed of light inside the ice cube. [2]

$\frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1} \rightarrow v_2 = (3\times10^8)\times\frac{\sin 33}{\sin 46}$

$= 2.27\times10^8\ ms^{-1}$

2

(ii) Show that no light emerges from side AB. [3]

$\Rightarrow \sin\theta_c = \frac{n_2}{n_1} \rightarrow \theta_c = \arcsin\left(\frac{n_3}{n_2}\right)$

$\Rightarrow n_2 = n_1\frac{\sin\theta_2}{\sin\theta_3} = \boxed{\frac{\sin 33}{\sin 46}}$ $= \arcsin\left(\frac{\sin 33/\sin 46}{1}\right)$

$= 49.212°$

$\Rightarrow$ As $57° > 49.212°$, total internal reflection occurs

3

(iii) Sketch, on the diagram, the subsequent path of the light ray. [2]

(This question continues on the following page)

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(Question 4 continued)

(b) Each side of the ice cube is 0.75 m in length. The initial temperature of the ice cube is –20 °C.

(i) Determine the energy required to melt all of the ice from –20 °C to water at a temperature of 0 °C. [4]

Specific latent heat of fusion of ice	$= 330\ \text{kJ kg}^{-1}$
Specific heat capacity of ice	$= 2.1\ \text{kJ kg}^{-1}\ \text{K}^{-1}$
Density of ice	$= 920\ \text{kg m}^{-3}$

DATA

$V = 0.75^3$

$T_i = -20°C$

$T_f = 0°C$

$C_i = 2.1 \times 10^3\ J\,kg^{-1}K^{-1}$

$L_i = 330 \times 10^3\ J\,kg^{-1}$

$\rho_i = 920\ kg\,m^{-3}$

$\rho = m/V$

$\therefore m = 920 \times 0.75^3 = 388.125\ kg$

$\therefore Q = mc \times 20 + mL$

$= 388.125(2.1 \times 10^3 \times 20 + 330 \times 10^3)$

$= 1.443825 \times 10^8\ J$

$\approx 144\ MJ$

4

(ii) Outline the difference between the molecular structure of a solid and a liquid. [1]

⇒ molecules in a solid form a lattice : tightly bound particles which vibrate

⇒ molecules in a liquid are free to move around however still feel attraction to other molecules

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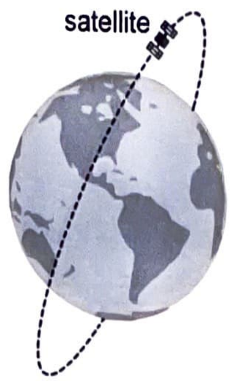
Turn over

5. A satellite powered by solar cells directed towards the Sun is in a polar orbit about the Earth.



The satellite is orbiting the Earth at a distance of 6600 km from the centre of the Earth.

(a) Determine the orbital period for the satellite. [3]

Mass of Earth $= 6.0 \times 10^{24}$ kg

DATA $M_E = 6.0 \times 10^{24}$ kg $r = 6600$ km	$g = 6.67\times10^{-11} \times 6.0\times10^{24} \div (6600000)^2$ $= 9.187 \cancel{\times 10}\ ms^{-2}$ $\therefore a = \frac{4\pi r}{T^2} \rightarrow T = \sqrt{\frac{4\pi r}{a}}$ $= \sqrt{\frac{4\pi^2 \times 6600000}{9.187}}$ $= 5326$ s ~~= 95.0 s~~ 3

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(Question 5 continued)

(b) The satellite carries an experiment that measures the peak wavelength emitted by different objects. The Sun emits radiation that has a peak wavelength λ_S of 509 nm. The peak wavelength λ_E of the radiation emitted by the Earth is 10.1 μm.

(i) Determine the mean temperature of the Earth. [2]

$$T = \frac{2.90 \times 10^{-3}}{10.1 \times 10^{-6}}$$
$$= 287.129 \text{ K}$$
$$\approx 287 \text{ K}$$

2

(ii) Suggest how the difference between λ_S and λ_E helps to account for the greenhouse effect. [3]

⇒ $\lambda \propto 1/T$ → $T_S >> T_E$ due to $\lambda_S << \lambda_E$

⇒ due to $P = e\sigma AT^4$, the power output of the sun, hence also the absorbtion of the ~~ear~~ Earth is greater than the power output (radiation) of Earth.

⇒ Hence, the Earth is a net absorber, which is contributed to by the greenhouse effect!

(c) Not all scientists agree that global warming is caused by the activities of man. Outline how scientists try to ensure agreement on a scientific issue. [1]

· releasing scientific publications / journals, which methodologically work through evidence to create theories, whilst at the same time falsifying redundant ideas.

1

- peer review
- international collaboration

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