Neap:

Trial Examination 2016

VCE Physics Units 3&4

Written Examination

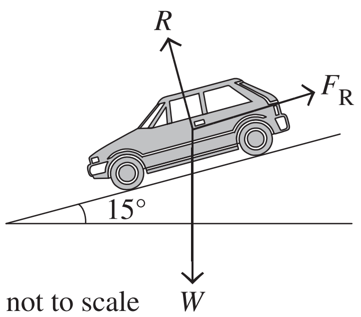
Suggested Solutions

SECTION A – CORE

Area of study – Motion in one and two dimensions

Question 1 (7 marks)

a.



3 marks
1 mark for each correctly labelled force arrow.

b. The weight force W can be resolved into two components.

Along the plane, $W\sin 15° = F_R$. — 1 mark

The size of the frictional force $F_R = 3106$ N. — 1 mark

c. The weight force W can be resolved into two components.

Perpendicular to the plane, $W\cos 15° = R$. — 1 mark

The size of the reaction force $R = 11\ 590$ N. — 1 mark

Question 2 (2 marks)

a. $$\text{average speed} = \frac{(4.0 \times 10^7)}{(6 \times 24 \times 60 \times 60)}$$

$$= 77.2 \text{ m s}^{-1}$$ 1 mark

b. average velocity = 0 m s^{-1} — 1 mark
(This is because her displacement is zero.)

Question 3 (6 marks)

a. $mv = 1000 \times 15$

$= 1.5 \times 10^4 \text{ kg m s}^{-1}$ — 1 mark

b. Momentum is conserved in all collisions. Total combined mass is 5000 kg.

$5000v = 1.5 \times 10^4 \text{ kg m s}^{-1}$ — 1 mark

$v = 3.0 \text{ m s}^{-1}$ — 1 mark

c. This is an example of an inelastic collision where the lost energy is converted to heat and sound. — 1 mark

$KE_{before} = 0.5\ (1000)\ (15)^2 = 112\ 500$

$KE_{after} = 0.5\ (5000)\ (3)^2 = 22\ 500$ — 1 mark

$KE_{lost} = 90\ 000$ J — 1 mark

Question 4 (5 marks)

a. Assume mass m accelerates down with an acceleration of *a* (if the equations solve with *a* being negative, then the mass must be accelerating up). Let the tension in the string be *T* and call 'down' positive.

Then in the vertical direction using Newton's second law:

$mg - T = ma$

$20 - T = 2a$ **Eq. (1)**

For mass M accelerating up the plane, Newton's second law gives:

$T - mg\sin 45° = ma$

$T - 14.14 = 2a$ **Eq. (2)** 1 mark

Adding **Eq. (1)** and **Eq. (2)** gives $20 - 14.14 = 4a$.

$a = 1.46$

$= 1.5 \text{ m s}^{-2}$ 1 mark

As *a* is positive, it means that mass m is moving DOWN. 1 mark

b. $20 - T = 2a$ **Eq. (1)** 1 mark

$T = 20 - 2a$

$= 20 - 3$

$= 17 \text{ N}$ 1 mark

Question 5 (6 marks)

a. $R = \dfrac{V^2 \sin(2\theta)}{g}$

$V = \sqrt{\dfrac{Rg}{\sin(2\theta)}}$

$= \sqrt{\dfrac{104.8 \times 10}{\sin(80)}}$ 1 mark

$= 32.6 \text{ m s}^{-1}$ 1 mark

b. $V_{\text{H}} t = R$

$t = \dfrac{104.8}{32.6\cos 40°}$ 1 mark

$= 4.2 \text{ s}$ 1 mark

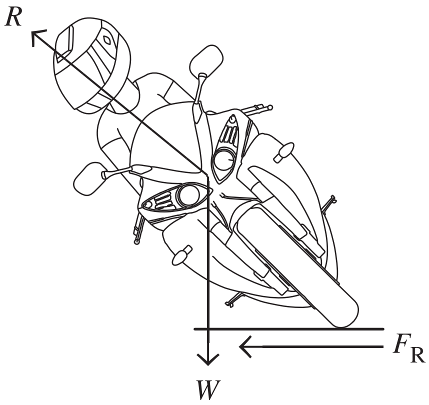
c. The maximum height reached by the javelin can be determined using the formula $s = 0.5gt^2$ where $t = 2.1$ s (as it takes half the total time to fall back to ground level from the maximum height). 1 mark

$s = 0.5(10)(2.1)^2$

$= 22.1 \text{ m}$ 1 mark

Question 6 (4 marks)

Three forces are acting on Ana as shown below: the weight force $W = mg$, the reaction force R and the frictional force F_R.



vertical forces: $R\cos 50° = mg$

$$R = \frac{mg}{\cos 50°} \qquad \textbf{Eq. (1)}$$

horizontal forces: $\frac{mv^2}{r} = R\sin 50° + F_R$ **Eq. (2)**

Substitute **Eq. (1)** into **Eq. (2)**.

$\frac{mv^2}{r} = mg\tan 50° + F_R$

$= \frac{(120)(40)^2}{100}$ 1 mark

$= (120)(40)\tan 50° + F_R$ 1 mark

$F_R = 490$ N 1 mark

direction: to the left 1 mark

Question 7 (4 marks)

a. For spring A:

$\Delta F_A = k_A \Delta x$

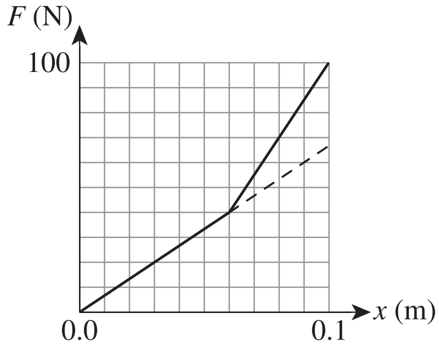
$40 = k_A(0.06)$

$k_A = 667 \text{ N m}^{-1}$ 1 mark

For spring B:

$\Delta F_B = k_B \Delta x$

Using $\Delta F_A = k_A \Delta x$ gives $\Delta F_A = 66.7$ N when $\Delta x = 0.1$ m (see dashed line on graph below).



Therefore:

$\Delta F_B = 100 - 66.7$

$= 33.3$ N

$33.3 = k_B(0.04)$

$k_B = 835 \text{ N m}^{-1}$ 1 mark

b. This is given by the area under the graph. This is made up of two triangles and a rectangle.

area = (0.5)(40)(0.06) + (0.5)(60)(0.04) + (40)(0.04) 1 mark

= 4.0 J 1 mark

Question 8 (6 marks)

a. The period of the orbit of Skylab around the Earth can be determined using:

$T = \sqrt[2]{\dfrac{4\pi^2 R^3}{GM}}$ 1 mark

$= \sqrt[2]{\dfrac{4\pi^2(6.613 \times 10^6)^3}{(6.67 \times 10^{-11})(5.98 \times 10^{24})}}$ 1 mark

= 5352 s

= 89.2 min 1 mark

Note that the radius of orbit is the radius of Earth (6.378×10^6 m) plus the height above the Earth (2.35×10^5 m).

b. As the astronauts orbit the Earth, they still have their *weight* ($W = mg$ – although g is slightly smaller than on Earth at an orbit height of 235 km). 1 mark

They appear to 'float' around the cabin because they are falling with an acceleration that is the same as the acceleration of Skylab to the Earth. This is called *apparent weightlessness*. 1 mark

True weightlessness only occurs when the astronauts are completely away from any masses. This does not apply to them when they are in orbit around the Earth. 1 mark

Area of study – Electronics and photonics

Question 9 (6 marks)

a. $V_{30} = 18 - V_X$

$= 18 - 15$

$= 3\ V$ 1 mark

b. $R = \frac{V_R}{I_R}$

$V_R = V_X - 9$

$= 15 - 9$

$= 6\ V$ 1 mark

$I_R = I_{30} = \frac{V_{30}}{30}$

$= \frac{3}{30}$

$= 0.1\ A$ 1 mark

$R = \frac{6}{0.1}$

$= 60\ \Omega$ 1 mark

Note: Consequential on answer to ***Question 9a.***

c. $P_R = VI$

$= 6 \times 0.1$ 1 mark

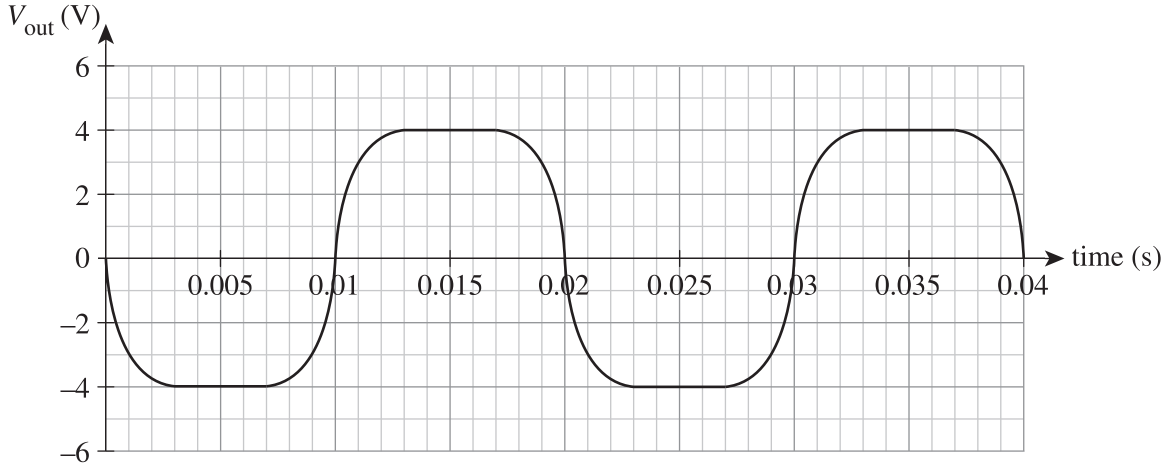
$= 0.6\ W$ 1 mark

Note: Consequential on answer to ***Question 9b.***

Students can also use $P = \frac{V^2}{R}$ *or* $P = I^2R$.

Question 10 (7 marks)

a.



3 marks
1 mark for clipping occurring at 4 V.
1 mark for signal = inverted.
1 mark for same period as input signal.

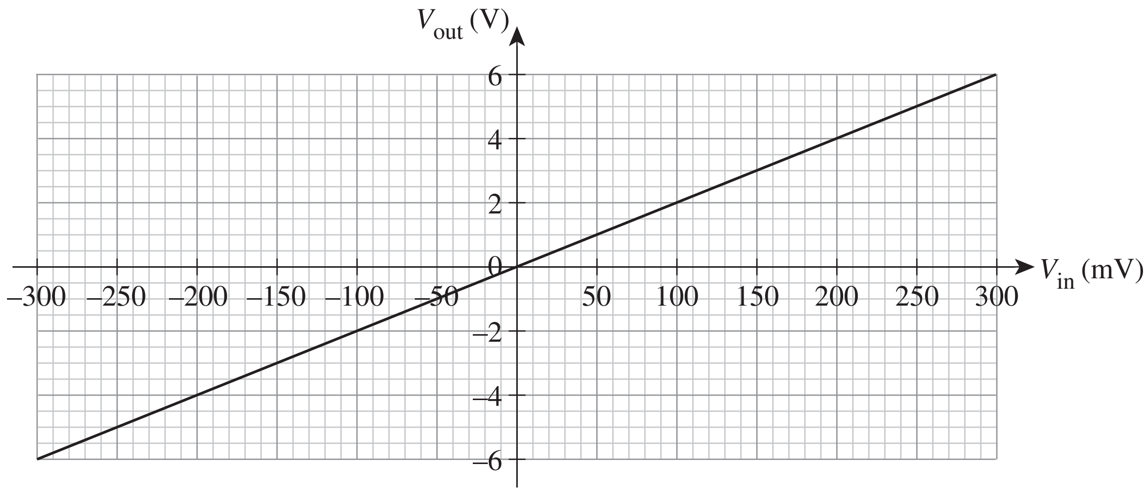
b. $\text{gain} = \dfrac{\text{amplitude } V_{out}}{\text{amplitude } V_{in}}$

$= \text{magnitude of gradient}$

$= \dfrac{4}{0.2}$ 1 mark

$= 20$ 1 mark

c.



2 marks
1 mark for positive gradient of value 20.
1 mark for amplification region allowing –250 to 250 mV as minimum domain.

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Question 11 (5 marks)

a. X must be signal C, which consists of the carrier and information signal. 1 mark

Y must be signal B, which consists of the information signal awaiting amplification. 1 mark

Z must be signal B, which consists of the information signal. 1 mark

b. The new signal D is less intense 1 mark
and so the information component is different to the information component of signal C, since the modulated signal intensity is proportional to the information it represents. 1 mark

Question 12 (6 marks)

a. 50 kΩ (read from the graph) 1 mark

b. $V_{\text{variable resistor}} = 5 \text{ V}$ and $V_{\text{thermistor}} = 9 - 5 = 4 \text{ V}$. 1 mark

Thus by voltage division, $\dfrac{R_{\text{variable resistor}}}{R_{\text{thermistor}}} = \dfrac{V_{\text{variable resistor}}}{V_{\text{thermistor}}}$

$$\therefore \frac{R_{\text{variable resistor}}}{50} = \frac{5}{4}$$

$$R_{\text{variable resistor}} = 50 \times \frac{5}{4}$$

$$= 62.5 \text{ k}\Omega$$

1 mark

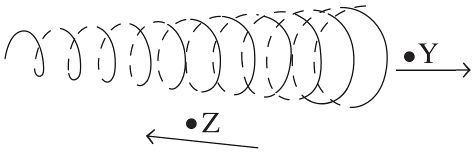
c. At 30° C the resistance of the thermistor is less than it is at 25° C. 1 mark

Thus to maintain the same voltage ratio for operation of the cooling unit switching, the ratio of resistances must also be the same, 1 mark
and so the resistance of the variable resistor needs to decrease as well by population. 1 mark

Area of study – Electric power

Question 13 (3 marks)

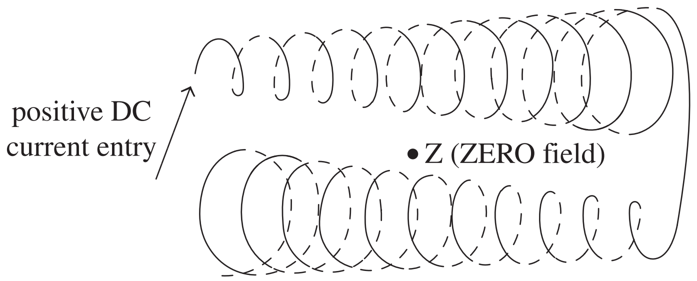
a.



At Y the field is to the right (using the right-hand grip rule). 1 mark

At X the field is parallel to the slope of the line connecting the lowest ends of the coil (using the right-hand grip rule). 1 mark

b.

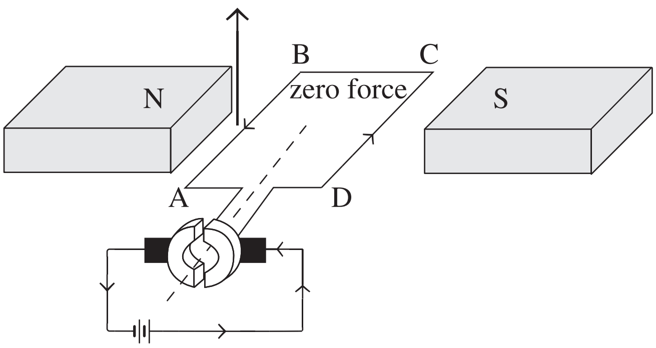


The resulting field is ZERO. 1 mark

(The field of the upper coil is to the left and parallel to the line of the lowest points of the coil. The field of the lower coil is to the right and parallel to the line of the highest points on the coil. These two fields are equal and opposite and so cancel each other.)

Question 14 (9 marks)

a.



The force on side AB is vertically up (due to the right-hand palm rule). 1 mark

The force on side BC is zero since the current in BC and the magnetic field directions are parallel. 1 mark

b. $F = NBIl\sin(\theta)$

$0.48 = 75 \times 0.080 \times I \times 0.04 \times \sin(90)$ 1 mark

$I = \frac{0.48}{0.24}$

$= 2.0 \text{ A}$ 1 mark

c. The splits in the ring enables the ends of the coil to disconnect from their current half-ring and then reconnect to the other half-ring. 1 mark

This enables the current direction to change and occurs every half-cycle of rotation. 1 mark

This also enables the forces acting on the sides to change every half-cycle so that continuous rotation of the coil is maintained. 1 mark

d. A solid ring effectively creates a parallel circuit where the current would prefer to pass through the ring of lower resistance than the wire coil. Thus the net current through the coil would be zero. 1 mark

The coil would not experience any forces and so would not rotate. 1 mark

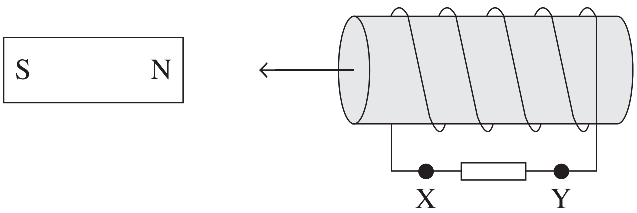
OR

Without a split in the ring, the current would reverse in direction when the coil becomes vertical. 1 mark

The coil would overshoot the vertical position and the forces remain in the same direction, causing the coil to oscillate briefly and stop in the vertical position. 1 mark

Question 15 (11 marks)

a.



It does this by producing its own flux to the left as shown above. 1 mark

The coil experiences an increasing external flux to the right. 1 mark

Thus the coil opposes the change in external flux by reducing the increase to the right. 1 mark

b. The induced flux to the left has an associated current according to the right-hand grip rule (thumb direction = positive current and fingers direction = flux). 1 mark

Thus the current is from X through the resistor to Y. 1 mark

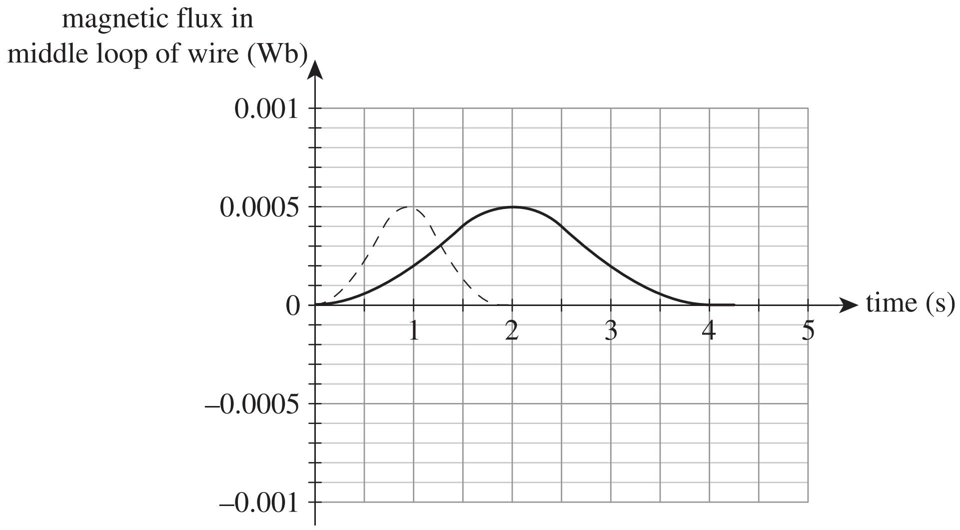
Note: Consequential on answer to ***Question 15a.***

c. $\text{EMF} = \left|\frac{\Delta\phi}{\Delta\tau}\right|$

$= \frac{0.0005}{2}$ 1 mark

$= 0.00025$ V 1 mark

d.

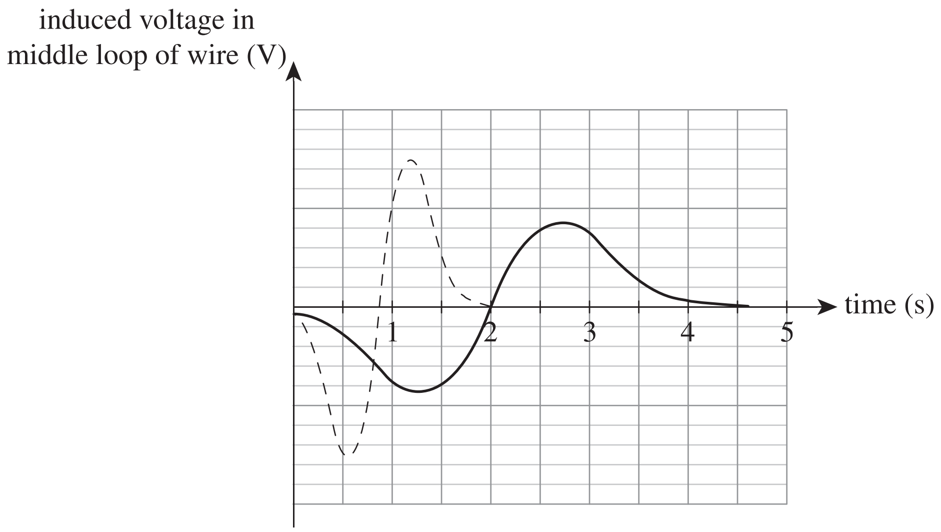


2 marks

1 mark for same maximum flux.

1 mark for variation occurring over two seconds.

e.



2 marks

1 mark for same profile but with double the maximum (peak and trough voltage values).

1 mark for time of the voltage variation now being two seconds.

Question 16 (7 marks)

a. period = $\frac{1}{2.5}$

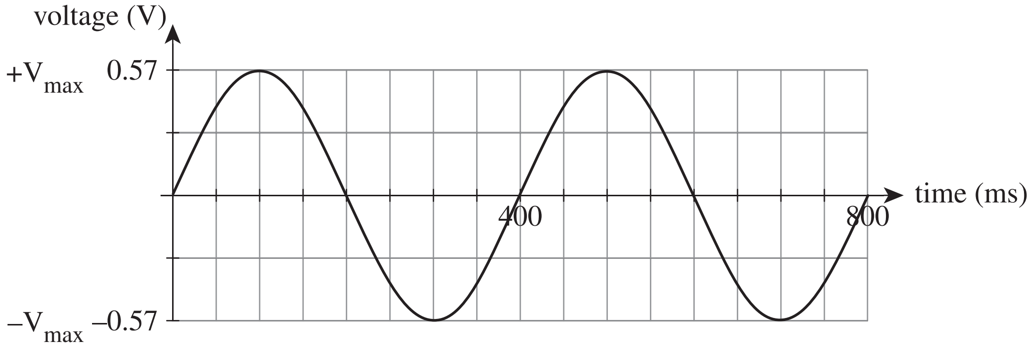
= 0.4 sec 1 mark

= 400 ms 1 mark

peak voltage = RMS (multimeter voltage) × $\sqrt{2}$

= 0.40 × 1.414

= 0.57 V 1 mark



2 marks

1 mark for scale marking on time axis.

1 mark for scale marking on voltage axis.

b. A coil end always touches the same slip-ring. 1 mark

This enables the voltage polarity to be maintained so as to produce a continuous sinusoidal (AC) signal. 1 mark

Question 17 (6 marks)

a. $\frac{\text{number of turns on the secondary coil of the switchyard transformer}}{\text{number of turns on the primary coil of the switchyard transformer}} = \frac{V_{secondary}}{V_{primary}}$

$= \frac{500}{20}$

= 25 1 mark

b. $I_{line}(\text{RMS}) = \frac{P_{generator}}{V_{transformer}}$

$= \frac{400 \times 10^6}{500 \times 10^3}$

= 800 A 1 mark

$I_{peak} = 800 \times \sqrt{2}$

= 1131 A 1 mark

c. $\%P_{\text{loss}} = \dfrac{P_{\text{loss}}}{P_{\text{generator}}} \times 100,\ P_{\text{loss}} = I^2R$ 1 mark

$$1.6 = \frac{800^2 \times R \times 100}{400 \times 10^6}$$ 1 mark

$$R = \frac{1.6 \times 400 \times 10^6}{800^2 \times 100}$$

$$= 10\ \Omega$$ 1 mark

Note: Consequential on answer to ***Question 17b.***

Area of study – Interactions of light and matter

Question 18 (6 marks)

a. **A** 2 marks

Point O is the central maximum, so you would expect to see a bright band due to constructive interference on the screen.

b. Point P represents a path difference of 2.5λ. 1 mark

$2.5\lambda = 2.5 \times 400 = 1000$ nm 1 mark

c. If the distance *d* between the two slits is made smaller, then the interference pattern on the screen will spread out, 1 mark

as the fringe spacing is inversely proportional to *d*. 1 mark

Question 19 (6 marks)

a. Einstein's formula refers to the maximum kinetic energy (KE_{max}) of the ejected electron as some electrons that come from deeper down than the metal surface 1 mark

will have less kinetic energy. 1 mark

b. The threshold frequency (f_0) for potassium represents the frequency at which the photoelectric effect 'turns on'. This is when $hf_0 = W$.

$$f_0 = \frac{(2.3)}{(4.14 \times 10^{-15})}$$ 1 mark

$$= 5.6 \times 10^{14} \text{ Hz}$$ 1 mark

c. If an electron is ejected with a maximum kinetic energy of 1.7 eV, then the incoming photon energy must be 4.0 eV (2.3 + 1.7). 1 mark

The wavelength of the photon is given by rearranging $E = hf = \frac{hc}{\lambda}$.

$$\lambda = \frac{(4.14 \times 10^{-15})(3.0 \times 10^{8})}{(4.0)}$$

$$= 3.1 \times 10^{-7} \text{m}$$ 1 mark

Question 20 (4 marks)

a. The value of highest frequency light emitted by mercury is in the transition from the 7.73 eV state back to the ground state. 1 mark

$$E = hf$$

$$f = \frac{7.73}{(4.14 \times 10^{-15})}$$

$$= 1.87 \times 10^{15} \text{ Hz}$$ 1 mark

b. The longest wavelength light that is emitted by mercury is the one involving the least energy in the transition. From Figure 26, this is from 8.84 eV to 6.70 eV = 2.14 eV. 1 mark

$$\lambda = \frac{(4.14 \times 10^{-15})(3.0 \times 10^{8})}{(2.14)}$$

$$= 5.8 \times 10^{-7} \text{ m}$$ 1 mark

Question 21 (4 marks)

a.

$$\lambda = \frac{h}{p}$$

$$= \frac{(6.63 \times 10^{-34})}{(1.673 \times 10^{-27})(2 \times 10^{6})}$$ 1 mark

$$= 1.98 \times 10^{-13} \text{ m}$$ 1 mark

b. **A** 2 marks

The ratio of the de Broglie wavelength of a proton to an electron both travelling at the same speed is $\frac{1}{1836}$, as the wavelength is inversely proportional to the momentum (*mv*).

Question 22 (5 marks)

a.

$$\text{photon momentum} = \frac{h}{\lambda}$$

$$= \frac{(6.63 \times 10^{-34})}{(2.0 \times 10^{-10})}$$ 1 mark

$$= 3.3 \times 10^{-24} \text{ kg m s}^{-1}$$ 1 mark

b. The electrons will have virtually the same wavelength as the X-rays if they produce very similar patterns. 1 mark

The kinetic energy of the electrons that would produce the diffraction pattern is given by:

$$\text{KE} = \frac{p^2}{2m}$$

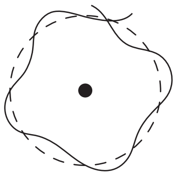
$$= \frac{\left(\frac{h}{\lambda}\right)^2}{2m}$$

$$= \frac{\left(\frac{(6.63 \times 10^{-34})}{(2.0 \times 10^{-10})}\right)^2}{(2 \times 9.1 \times 10^{-31})}$$ 1 mark

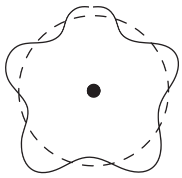
$$= 6.0 \times 10^{-18} \text{ J}$$ 1 mark

An alternative method is to calculate the speed of the electron (3.6×10^6 m s^{-1}) and then use KE = 0.5 mv^2.

Question 23 (3 marks)



4.5λ



5λ

1 mark for drawing the 4.5λ diagram correctly.
2 marks for drawing the 5λ diagram correctly.

SECTION B – DETAILED STUDY (2 marks for each correct answer)

Detailed study 1 – Einstein's special relativity

Question 1 D

Option **D** is the only true statement.

Question 2 A

Classical physics assumes the speed of light is variable and so predicts a relative speed of $c - v$.

In modern physics the speed of light is constant in all inertial frames of reference; that is, c.

Question 3 C

Option **A** became true later, only when special relativity was formulated by Einstein. Option **B** is not fully correct as it assumes the aether was in existence but was not able to be detected. Option **D** is an incorrect statement.

Question 4 B

Proper lengths can only be measured in the rest frame relative to the space station.

Question 5 B

The Lorentz factor is given by:

$$\gamma = \frac{\text{proper length}}{\text{measured length}}$$

$$= \frac{300}{198}$$

$$= 1.515$$

Question 6 C

The Lorentz factor in relation to speed is given by:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\therefore v = c \times \sqrt{1 - \frac{1}{\gamma^2}}$$

$$= c \times \sqrt{1 - \frac{1}{1.25^2}}$$

$$= c \times 0.6$$

Question 7 **A**

measured time in moving frame = proper time in rest frame × γ

$$7.5 = 4.5 \times \gamma$$

Measured time is always dilated and so $\gamma = \frac{7.5}{4.5}$

$$= 1.667$$

Thus $v = c \times \sqrt{1 - \frac{1}{\gamma^2}}$

$$= c \times \sqrt{1 - \frac{1}{1.667^2}}$$

$$= c \times 0.80$$

$$\frac{v}{c} = 0.80$$

Question 8 **C**

The answer is found based on the definition of how time is measured using clocks and the observation of events.

Question 9 **D**

An energy of 4.367×10^{-12} has a mass equivalent given by:

$$\Delta E = mc^2$$

$$\therefore m = \frac{4.367 \times 10^{-12}}{(3.0 \times 10^8)^2}$$

$$= 4.852 \times 10^{-29} \text{ kg}$$

Given that the energy and therefore its mass equivalent is released upon the combination, the final mass is lessened by 4.852×10^{-29} kg.

Question 10 **B**

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

relativistic mass = rest mass × γ

$$= \frac{M_0 \times 1}{\sqrt{1 - 0.7^2}}$$

$$= M_0 \times 1.4$$

$$= M_0(1 + 0.4)$$

Thus the spacecraft mass is greater by $0.4M_0$.

Question 11 **A**

$$\begin{aligned}\text{kinetic energy} &= M_0c^2(\gamma - 1)\\ &= M_0c^2(1.4 - 1)\\ &= 0.4M_0c^2\end{aligned}$$

Detailed study 2 – Materials and their use in structures

Question 1 B

A downward force acting on the column means that the column is in compression. The largest downward force that the column can withstand without breaking can be determined using:

$$F = \sigma A$$
$$= (8.0 \times 10^{6})(2.0)$$
$$= 1.6 \times 10^{7} \text{ N}$$

Question 2 B

The stress versus strain graph shows that the stone is much weaker in tension than compression. The top of the lintel is under compressive stress and the bottom of the lintel is under tensile stress.

Question 3 D

The stress versus strain graph shows that X is both stronger and tougher than Y.

Y shows brittle failure whilst X shows plastic behaviour.

Question 4 B

The area under the stress versus strain graph for material Y is the toughness of the material and is given by:

$$0.5\sigma\varepsilon = (0.5)(3 \times 10^{8})(3 \times 10^{-3})$$
$$= 4.5 \times 10^{5} \text{ J m}^{-1}$$
$$= 0.45 \text{ MJ m}^{-3}$$

Question 5 A

Let the distance from Bob to the fulcrum point be x. Using the torque equation about the fulcrum point gives $(650)(x) = 250(4.5 - x)$, which solves for $x = 1.25$ m.

Question 6 C

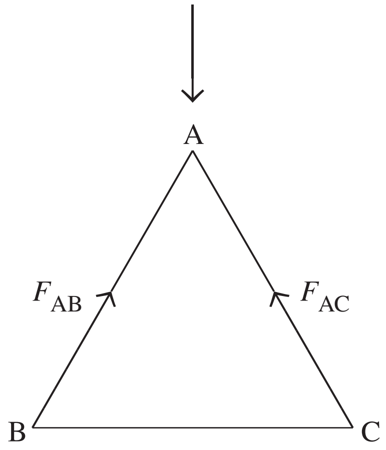
If the mass of the beam is included then the centre of mass of the beam is in the middle of the beam, which provides an extra clockwise torque to the system, making it unbalanced. This can be rectified by moving the fulcrum away from Bob and closer to Raz.

Question 7 B

A vertical force acting at point A causes sections AB and AC to be in compression, and BC in tension.

Question 8 B

The forces in sections AB and AC will be the same. Therefore $F_{AB} = F_{AC}$.

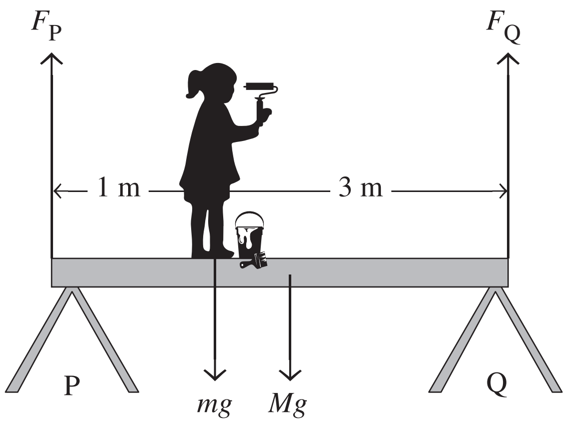


Resolving forces in the vertical direction:

$$2F_{AB}\cos(30°) = 20 \text{ kN}$$

$$F_{AB} = 11.6 \text{ kN}$$

Question 9 C



Taking clockwise and anti-clockwise moments about Q:

$$F_P \times 4 = (mg \times 3) + (Mg \times 2)$$

$$= (600 \times 3) + (1000 \times 2)$$

$$= 3800$$

$$F_P = 950 \text{ N}$$

Question 10 C

Diagram **A** shows tension, **B** compression and **C** shear.

Question 11 D

As cast iron is stronger in compression than in tension, and the bottom of the flange is under tension, more material needs to be placed there than at the top. Although both design **B** and **C** have the same bottom profile, they do not meet the criterion that material costs should be kept to a minimum.

Detailed study 4 – Synchrotron and its applications

Question 1 **B**

10 keV = 1.6×10^{-15} J

$$KE = \frac{1}{2}mv^2$$

$$\frac{1}{2}mv^2 = 6.4 \times 10^{-15} \text{ J}$$

$$v = \sqrt{\frac{(2)(1.6 \times 10^{-15})}{9.1 \times 10^{-31}}}$$

$$= 6.0 \times 10^7 \text{ m s}^{-1}$$

Question 2 **A**

As the mass of the proton is 1860 times heavier and the formula for velocity is $v = \sqrt{\frac{(2)(1.6 \times 10^{-15})}{\text{mass}}}$, the speed will be smaller.

Question 3 **A**

A proton beam travelling to the right is equivalent to a conventional current travelling to the right. The left-hand FBI rule or the right-hand slap rule gives the force on the proton beam as up.

Question 4 **C**

$$F = qvB$$

$$= (1.6 \times 10^{19})(1 \times 10^7)(2.0)$$

$$= 3.2 \times 10^{-12} \text{ N}$$

Question 5 **D**

$$F = \frac{mv^2}{R}$$

$$R = \frac{mv^2}{qvB} = \frac{mv}{qB}$$

$$= \frac{(1.67 \times 10^{27})(1.0 \times 10^7)}{(1.6 \times 10^{-19})(2.0)}$$

$$= 5.2 \times 10^{-2} \text{ m}$$

Question 6 **B**

The divergence of the beam produced by synchrotron radiation is the extent to which the beam spreads out as it travels down the beamline.

Question 7 **B**

The brightness of the beam produced by synchrotron radiation is the number of photons emitted per second within a specific narrow frequency range.

Question 8 C

$$\Delta E = \frac{hc}{\lambda_1} - \frac{hc}{\lambda_2}$$

$$= (6.63 \times 10^{-34})(3.0 \times 10^{8})\left(\frac{1}{8.6 \times 10^{-10}} - \frac{1}{9.6 \times 10^{-10}}\right)$$

$$= 2.4 \times 10^{-17} \text{ J}$$

Question 9 A

The form of scattering involved in the experiment is Compton scattering.

Question 10 C

Using Bragg's law, where λ is the wavelength and d is the atomic spacing:

$$n\lambda = 2d\sin\theta$$

$$\sin\theta = \frac{n\lambda}{2d}$$

$$= \left(\frac{2(0.5 \times 10^{-9})}{2(1.0 \times 10^{-9})}\right)$$

$$\theta = 30°$$

Question 11 D

Using Bragg's law:

$$\sin\theta = \frac{n\lambda}{2d}$$

$$n = 1,\ \sin\theta = \frac{1}{4}$$

$$n = 2,\ \sin\theta = \frac{1}{2}$$

$$n = 3,\ \sin\theta = \frac{3}{4}$$

$$n = 4,\ \sin\theta = 1$$

As the maximum value for $\sin\theta = 1$, then θ can have a maximum of only 4 different angles.

Detailed study 6 – Sound

Question 1 **C**

From the distance graph, the wavelength is 17 cm, which is the distance between successive compressions.

Question 2 **C**

period = 1 cycle of time from Figure 2.

$$\begin{aligned}\text{frequency} &= \frac{1}{\text{period}}\\ &= \frac{1}{500}\times 10^{6}\\ &= 2000\ \text{Hz}\end{aligned}$$

Question 3 **B**

$$\begin{aligned}I &= 1.0\times 10^{-12}\times 10^{\frac{L}{10}}\\ &= 1.0\times 10^{-12}\times 10^{\frac{80}{10}}\\ &= 1.0\times 10^{-4}\ \text{W m}^{-2}\end{aligned}$$

Question 4 **B**

Use the inverse square law for intensity.

$$Id^2_{\text{(position 1)}} = Id^2_{\text{(position 2)}}$$

$$1.0\times 10^{-4}\times 2.0^2 = I\times 6.0^2$$

$$\begin{aligned}I &= \frac{1.0\times 10^{-4}\times 2.0^2}{6.0^2}\\ &= 1.11\times 10^{-5}\end{aligned}$$

$$\begin{aligned}L &= 10\log\left(\frac{1.11\times 10^{-5}}{1.0\times 10^{-12}}\right)\\ &= 70.5\ \text{dB}\end{aligned}$$

Question 5 **B**

100 Hz at 80 dB corresponds approximately to the 75 phon curve; that is, Mary perceives the note at 75 dB.

Question 6 **A**

The $\frac{\lambda}{d} = \frac{v}{fd}$ ratio for room A is $\frac{330}{(1200\times 1.5)} = 0.18$.

The $\frac{\lambda}{d} = \frac{v}{fd}$ ratio for room B is $\frac{330}{(800\times 0.80)} = 0.51$.

Thus the note from room B diffracts more so around its doorway than the note from room A, and so will register a higher reading at position Y.

Question 7 D

Given that position A is at minimum intensity (node) and position B is at maximum intensity (antinode), these positions must be a quarter-wavelength apart.

Question 8 B

The pipe is open at both ends, so $\text{pipe length} = \frac{n \times \text{wavelength}}{2}$, where $n = 1, 2, 3\ldots$

Thus the other wavelengths are:

$$\frac{2 \times 0.99}{n} = \frac{1.98}{2}, \frac{1.98}{3}, \frac{1.98}{4}$$

$$= 0.99 \text{ m}, 0.66 \text{ m}, 0.495 \text{ m}$$

Question 9 B

The coil and magnetic field operate to produce a flux variation.

Question 10 B

High fidelity implies that a range of frequencies is played with equal loudness levels so that each frequency is perceived as equal loudness.

Question 11 A

The hard box reduces destructive interference effects due to the sound from the rear of the speaker.