Neap:

Trial Examination 2015

VCE Physics Units 3&4

Written Examination

Suggested Solutions

SECTION A – CORE

Area of study – Motion in one and two dimensions

Question 1 (8 marks)

a. 0 N — 1 mark

As Chris is travelling at a constant speed, $\Sigma \boldsymbol{F} = ma = 0$.

b. Down the plane, the force component of gravity is given by $mg\sin 30°$.

The total forces down the plane add to 0 N. — 1 mark

$\boldsymbol{F}_R = mg\sin 30°$ — 1 mark

$= (50)(10)(0.5)$

$= 250$ N — 1 mark

c. The normal reaction force, $\boldsymbol{F}_N$, is given by $mg\cos 30°$.

$\boldsymbol{F}_N = mg\cos 30°$ — 1 mark

$= (50)(10)(0.866)$

$= 433$ N — 1 mark

d. The correct answer is **D**. — 2 marks

$mg\sin 40° > \boldsymbol{F}_R$, so Chris will accelerate.

$\boldsymbol{F}_N = mg\sin 40° < mg\cos 30°$, so $\boldsymbol{F}_N$ will decrease.

Question 2 (2 marks)

Students can nominate any distance for journey, for example, 40 m.

$$t_{\text{there}} = \frac{40\text{ m}}{2\text{ m s}^{-1}} = 20\text{ s}$$

$$t_{\text{back}} = \frac{40\text{ m}}{4\text{ m s}^{-1}} = 10\text{ s}$$

$\therefore$ average speed $= \dfrac{\text{total distance}}{\text{total time}}$ — 1 mark

$= \dfrac{80\text{ m}}{30\text{ s}}$

$= 2.7\text{ m s}^{-1}$ — 1 mark

Question 3 (6 marks)

a. 1.2 tonne = 1200 kg

$72\text{ km h}^{-1} = 20\text{ m s}^{-1}$

$\boldsymbol{p} = 2.4 \times 10^4$ N s west — 2 marks

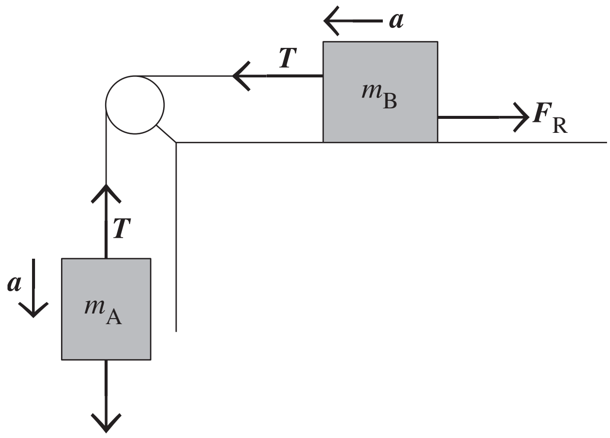
1 mark for momentum
1 mark for direction

b. All of the car's momentum has transferred — 1 mark
to the Earth via the tree. — 1 mark

c. All of the car's kinetic energy has been converted — 1 mark
into heat and sound. — 1 mark

Question 4 (4 marks)

a.



vertical equation: $20 - T = 2a$
horizontal equation: $T - 10a = 3a$ — 1 mark

$10 = 5a$

$a = 2\text{ m s}^{-2}$ — 1 mark

b. $20 - T = 2a$

$20 - T = 4$ — 1 mark

$T = 16\text{ N}$ — 1 mark

Consequential on ***Question 4a.*** *if the value of the acceleration is sensible.*

Question 5 (4 marks)

a. Using the range formula:

$$R = \frac{V^2 \sin 2\theta}{g}$$

$$V = \sqrt{\frac{Rg}{\sin 2\theta}} \quad \theta = 45°$$

$$= \sqrt{\frac{20.10}{1}}$$ 1 mark

$$= 14.14 \text{ m s}^{-1}$$ 1 mark

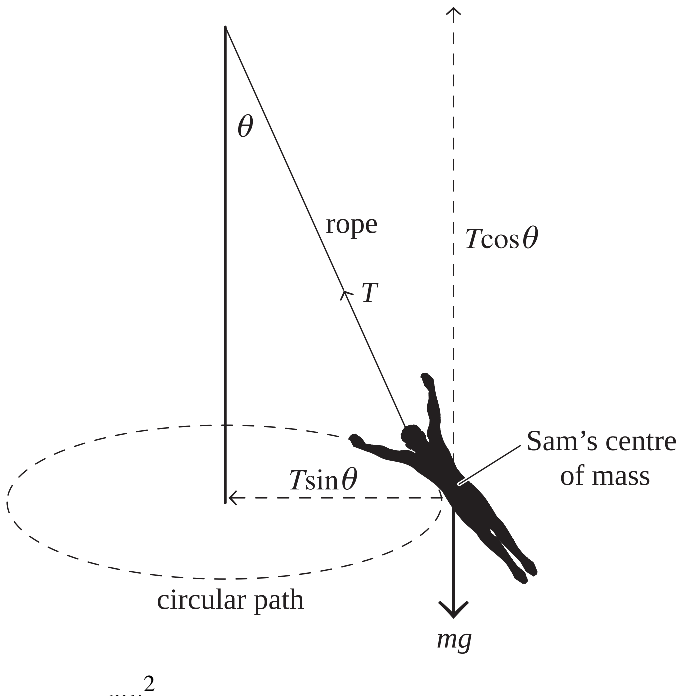
b. $$R_{30°} = \frac{V^2 \sin 60°}{g} = \frac{0.866V^2}{g}$$ 1 mark

$$R_{60°} = \frac{V^2 \sin 120°}{g} = \frac{0.866V^2}{g}$$ 1 mark

Students may use alternative methods to answer both parts of ***Question 5****.*

Question 6 (4 marks)

a.



$$T\sin\theta = \frac{mv^2}{R}$$

$$T\cos\theta = mg$$

$$\tan\theta = \frac{v^2}{Rg}$$

$$= \frac{16}{(6)(10)}$$ 1 mark

$$\theta = 14.9°$$ 1 mark

b. $T = \dfrac{mg}{\cos\theta}$

$= \dfrac{500}{\cos 14.9°}$ 1 mark

$= 517$ N 1 mark

Consequental on answer to ***Question 6a.***

Question 7 (5 marks)

a. $F = kx$

$k = \dfrac{5}{0.1}$

$= 50 \text{ N m}^{-1}$ 1 mark

b. 0.20 m 1 mark

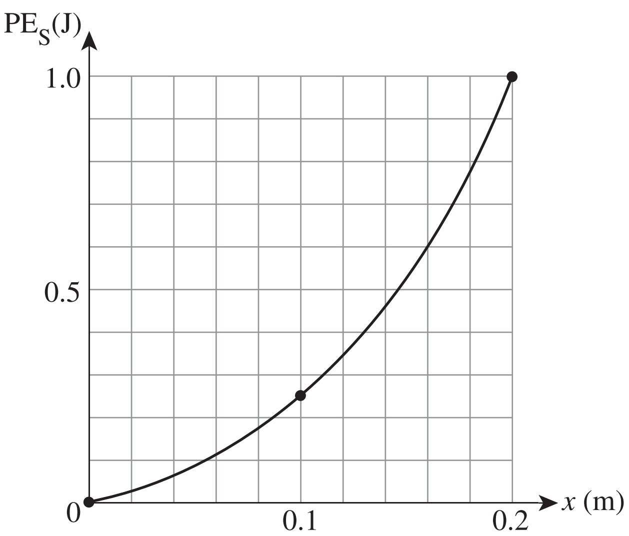
The force doubles, therefore the extension doubles.

c. $\text{PE} = \frac{1}{2}kx^2$

$\text{PE}_{\text{no mass}} = 0$

$\text{PE}_{0.5\text{ kg}} = \frac{1}{2}(50)(0.1)^2 = 0.25 \text{ J}$

$\text{PE}_{1.0\text{ kg}} = \frac{1}{2}(50)(0.2)^2 = 1.0 \text{ J}$



3 marks

1 mark for correct extension data points (0 m, 0.1 m and 0.2 m)

1 mark for correct PE data points (0 J, 0.25 J and 1.0 J)

1 mark for showing the quadratic nature of the PE graph

Question 8 (7 marks)

a. $\frac{R^3}{T^2} = \frac{GM}{4\pi^2}$ 1 mark

$R = \sqrt[3]{\frac{(6.67 \times 10^{-11})(5.98 \times 10^{24})(27.3 \times 24 \times 3600)^2}{4\pi^2}}$ 1 mark

$= 3.83 \times 10^8$ m 1 mark

b. $a = \frac{GM}{R^2}$

$= \frac{(6.67 \times 10^{-11})(5.98 \times 10^{24})}{(3.83 \times 10^8)^2}$ 1 mark

$= 2.7 \times 10^{-3}$ m s^{-2} 1 mark

Consequential on radius answer from ***Question 8a.***

c. The astronauts are in 'free fall'. They are accelerating to the Moon's surface at the same rate as the spacecraft. 1 mark

They feel 'apparent weightlessness'. 1 mark

Area of study – Electronics and photonics

Question 9 (3 marks)

Using the effective resistance for two resistors in parallel, $R_P = \frac{(R_1 \times R_2)}{R_1 + R_2}$:

- The two 48 Ω resistors give: $\frac{(48 \times 48)}{48 + 48} = 24\ \Omega$
- The 40 Ω and 10 Ω resistors give $\frac{(40 \times 10)}{40 + 10} = 8\ \Omega$

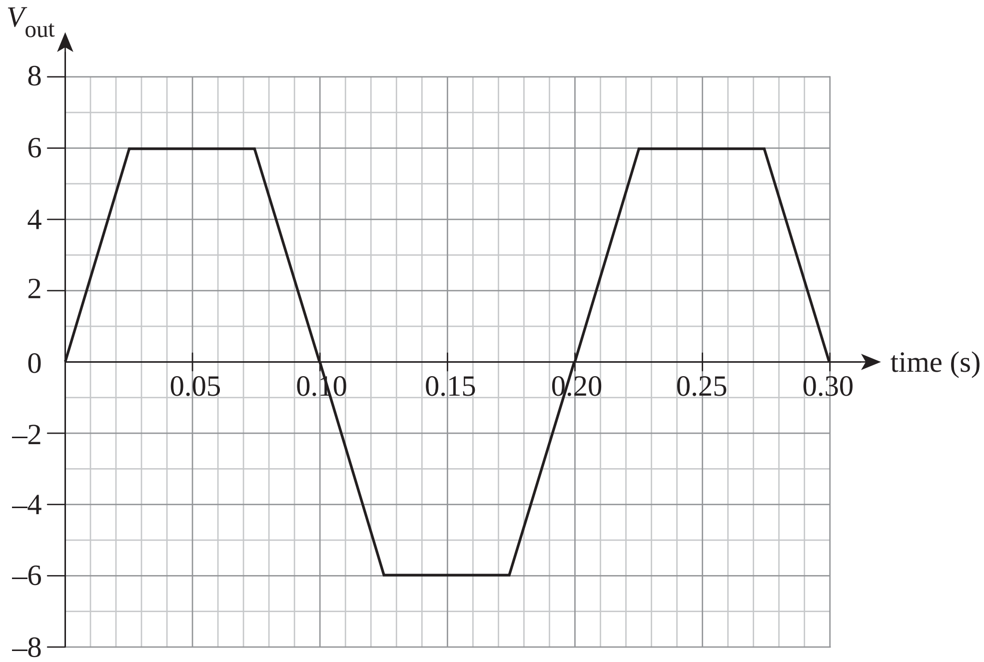
1 mark

Students must provide at least one of the two points above to be awarded the mark.

$V_{out} = \frac{12 \times 8}{24 + 8}$ 1 mark

$= 3$ V 1 mark

Question 10 (3 marks)



3 marks

1 mark for clipping occurring at time intervals 0.025–0.075 s, 0.125–0.175 s and 0.225–0.275 s (but must range from 0–0.3 s)

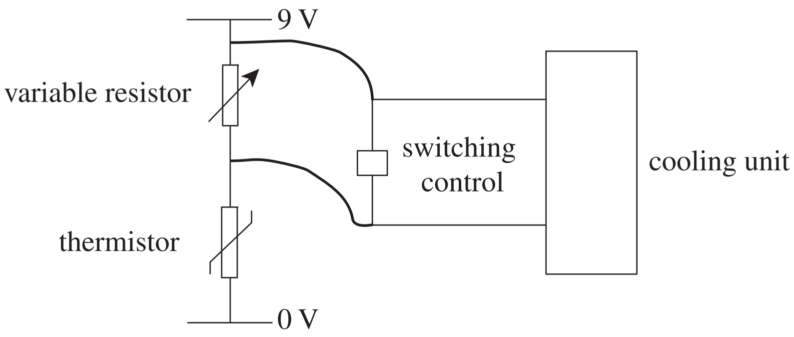
1 mark for clipping range of –6 V to +6 V

1 mark for output voltage being non-inverted

Question 11 (8 marks)

a. At 25°C, R = 40 kΩ (read from the graph). 1 mark

b. The switching control is placed in parallel across the device, whose voltage rises as the temperature rises.



1 mark

c. Let the variable resistance be R.

Using the voltage divider equation:

$$5\text{ V} = \frac{9 \times R}{40 + R}$$ 1 mark

$$5(40 + R) = 9R$$

$$200 + 5R = 9R$$ 1 mark

$$R = 50\text{ k}\Omega$$ 1 mark

d. At a higher temperature, the ratio of the thermistor-to-variable-resistor voltages is still to be 4 : 5. 1 mark

Thus the ratio of the resistances is to also remain the same.

At the higher temperature, the thermistor has a smaller resistance, 1 mark
and so for the ratio of the resistances to remain the same, the variable resistance value also needs to decrease. 1 mark

Question 12 (8 marks)

a. The LED has a maximum voltage of 2 V, and so the 100 Ω resistor has 12 – 2 = 10 V. 1 mark

$$I = \frac{10}{100}$$

$$= 0.1 \text{ A}$$

$$= 100 \text{ mA}$$ 1 mark

No marks are to be awarded if 0.1 is given in answer box.

b. At 20 mW the circuit current is 8 mA. 1 mark

resistor voltage = alarm voltage = 4 V

$$\text{resistance} = \frac{\text{voltage}}{\text{current}}$$

$$= \frac{4}{0.008}$$ 1 mark

$$= 500\ \Omega$$ 1 mark

c. Increasing R_1 increases the effective LED-circuit resistance and so draws less current. 1 mark

A lesser current results in less LED light emission, which in turn leads to a lower current in the photodiode circuit. 1 mark

Thus to achieve the same alarm system voltage at a lower current, the resistance value needs to increase. 1 mark

Question 13 (2 marks)

The input signal is a modulated signal and the output signal is the information signal only. The carrier signal has been removed by the electronic equipment. 1 mark

The process carried is demodulation. 1 mark

Area of study – Electric power

Question 14 (2 marks)

a. The correct answer is **D**. 1 mark

The magnetic field resulting from the wire coil is vertically down at Z using the right-hand grip rule.

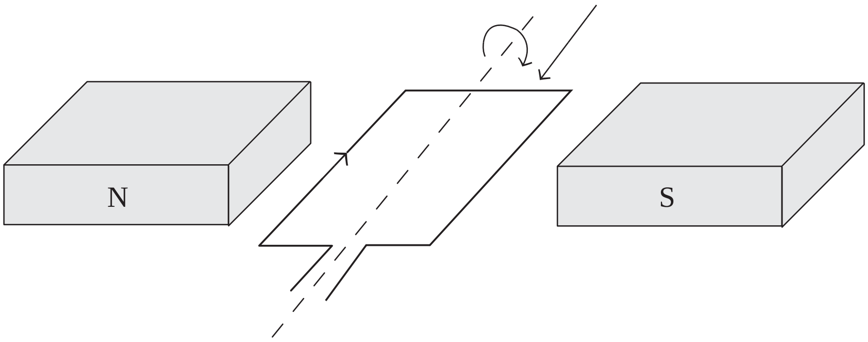
b. The correct answer is **E**. 1 mark

The current is to the right and the external magnetic field is down. By the right-hand slap rule, the force acting is into the page.

Consequential on answer to ***Question 14a.***

Question 15 (8 marks)

a.



1 mark

b. Immediately after the coil starts to turn, its area exposed to the external magnetic field increases, and so the coil experiences an external flux increase to the right. 1 mark

It opposes the change in flux by providing its own flux to the left through itself. 1 mark

c. This is determined by the right-hand grip rule (curl of fingers = induced flux, which is to the left), 1 mark

and the current (thumb) that corresponds to the induced flux is therefore **clockwise**. 1 mark

d. $\text{average current} = \dfrac{\text{average EMF}}{\text{resistance}}$

$\text{average EMF} = N(\Delta \Phi), \ \ N = 1$

$\Delta \Phi = \Phi_{\text{final}} - \Phi_{\text{intial}}$

$= (0.1 \times 0.04 \times 0.03) - 0$

$= 0.00012 \text{ Wb}$ 1 mark

$\Delta t = 0.5 \text{ s}$

$\text{average EMF} = \dfrac{0.00012}{0.5}$

$= 0.00024 \text{ V}$ 1 mark

$\text{average current} = \dfrac{0.00024}{0.01}$

$= 0.024 \text{ A}$ 1 mark

Question 16 (4 marks)

a. Since the current is constant, it leads to a constant magnetic field and flux around the transformer. 1 mark

As there is no changing flux, there is no induced voltage and hence zero output current. 1 mark

b. Using $\frac{I_2}{I_1} = \frac{N_1}{N_2}$:

$I_{peak} = 50 \text{ mA}, I(\text{RMS}) = \frac{I_{peak}}{\sqrt{2}}$

$I_2(\text{RMS}) = I_1(\text{RMS}) \times \frac{N_1}{N_2}$

$= \frac{50}{\sqrt{2}} \times \frac{9600}{480}$ 1 mark

$= 707.2 \text{ mA}$ 1 mark

Question 17 (11 marks)

a. $V_{loss} = I_{line} \times R_{line}$

$= 1.2 \text{ V}$ 1 mark

b. $P_{\text{variable resistor}} = P_{total} - P_{wiring}$

$= (V_{battery} \times I_{circuit}) - P_{wiring}$ 1 mark

$= (12 \times 0.60) - 0.60^2 \times 2.0)$

$= 7.2 - 0.72$ 1 mark

$= 6.48 \text{ W}$ 1 mark

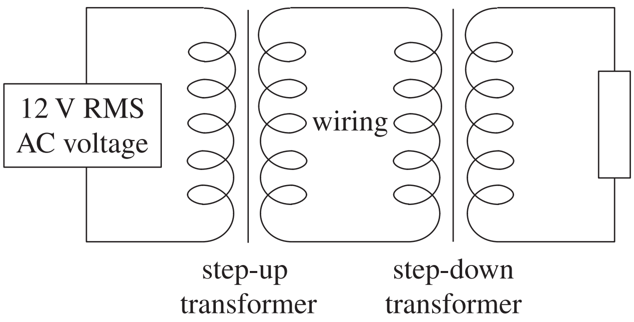
c. A voltage divider relation is required, or the ratio of voltages can be used.

$\frac{V_{resistance}}{V_{wiring}} = \frac{R_{resistance}}{R_{wiring}}$

$\frac{8}{4} = \frac{R_{resistance}}{2.0}$ 1 mark

$R_{resistance} = 4.0 \ \Omega$ 1 mark

d.



1 mark

All three modifications must be shown to be awarded the mark.
Labels must be included.

The supply voltage needs to be AC so that an alternating current can produce a changing flux. Its value needs to be 12 V RMS. 1 mark

For the resistor to have a greater power, there must be less power loss in the wiring. This is achieved by reducing the current in the wiring, since $P_{loss} = I_{line}{}^2 \times R_{line}$. 1 mark

The current is reduced by stepping up the voltage at the beginning of the wiring ($V_{transformer}$), since $I_{line} = \frac{P_{transmitted}}{V_{transformer}}$.
Thus a step-up transformer is required at the beginning of the wiring. 1 mark

In order for the resistance to receive 8 V, the voltage in the wiring is too high, and so needs to be stepped down. Thus a step-down transformer is required prior to the voltage reaching the resistance. 1 mark

Question 18 (5 marks)

a. Current passes from W to Z and the magnetic field is to the left. Thus the force is vertically down by the right-hand palm rule. 1 mark

b. $\boldsymbol{F} = N \times B \times I \times l$

$= 50 \times 0.20 \times 0.80 \times 0.30$ 1 mark

$= 2.4 \text{ N}$ 1 mark

c. In the vertical position, the coil is momentarily disconnected so that an open circuit exists. This is not the case for the circuit shown in Figure 23. 1 mark
As no current passes, there is no force on the sides of the coil. 1 mark

Question 19 (6 marks)

a. $x = 3$ periods of time

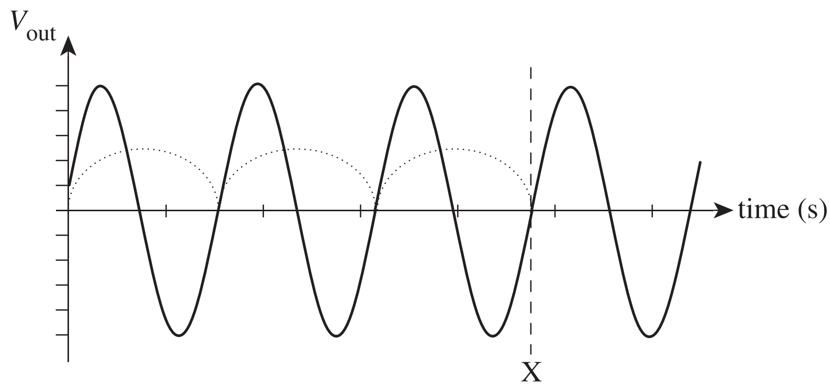
1 period $= \frac{1}{4.0} = 0.25 \text{ s}$ 1 mark

$x = 3 \times 0.25$ 1 mark

$= 0.75 \text{ s}$

$\approx 0.8 \text{ s}$ 1 mark

b.



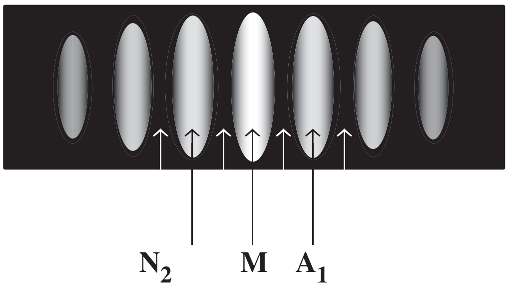
3 marks

1 mark for the amplitude of the EMF is halved
1 mark for the period of the EMF is doubled
1 mark for the commutator causes the output to be DC (positive is shown above but negative is also acceptable); that is, the polarity is reversed every half-cycle as a result of the swapping of the coil connections every half-rotation

Area of study – Interactions of light and matter

Question 20 (6 marks)

a.



2 marks

Award 1 mark if only two labels are correct.

b.

Label	M	A_1	N_2
Path difference (nm)	0	530	795

This is because the path differences are respectively 0 λ for M; 1 λ for A_1 and 1.5 λ for N_2.

2 marks

Award 1 mark if only two path differences are correct.

c. The interference experiment supports the wave model of light, 1 mark
and the experiment shows the effects of constructive (antinodes) and destructive (nodes) interference, which is a wave property. 1 mark

Question 21 (7 marks)

a. The concept of threshold frequency in the photoelectric effect is that it is the minimum frequency of light required to be incident upon the photocathode of the photocell, 1 mark
which causes ejection of electrons from the photocathode. 1 mark

b. Photon energy for blue light is:

$E = hf$

$= (4.14 \times 10^{-15})(6.3 \times 10_{14})$

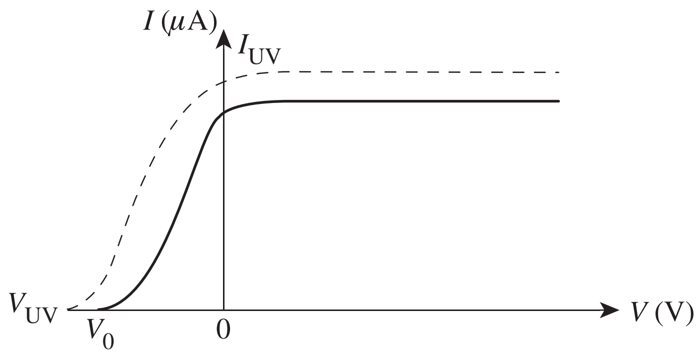
$= 2.6$ eV 1 mark

This causes the electrons to be ejected with a maximum KE of 0.3 eV. 1 mark

Therefore the threshold frequency for sodium, f_0, is given by $hf_0 = 2.3$ eV, which gives an f_0 value of sodium of 5.6×10^{14} Hz. 1 mark

Students must show working for full marks.

c.



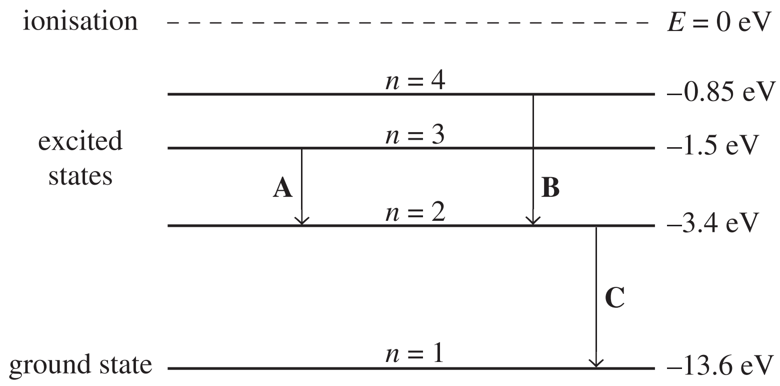
The curve expected if ultraviolet light of a higher intensity is used in the experiment instead of the blue light has two important characteristics:

- V_{UV}: a larger cut-off voltage (as UV has a higher frequency than blue light) — 1 mark
- I_{UV}: a higher current (as a greater number of photons eject a greater number of electrons) — 1 mark

This is shown by the dashed line above.

Question 22 (5 marks)

a.



3 marks

1 mark for each correct label

The arrows must point down.

b. The longest wavelength photon corresponds to the smallest frequency, which in turn corresponds to the smallest energy jump.

$E_{4-3} = 0.65 \text{ eV} = hf = \frac{hc}{\lambda}$ — 1 mark

$\lambda = 1.88 \times 10^{-6}$ m — 1 mark

Question 23 (6 marks)

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

$= \frac{(6.63 \times 10^{-34})}{(5.0 \times 10^{-2} \times 40)}$ — 1 mark

$= 3.3 \times 10^{-34}$ m — 1 mark

b. **unobservable/impossible** 1 mark

Both correct terms must be circled to be awarded mark.

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

$= \frac{(6.63 \times 10^{-34})}{(9.1 \times 10^{-31} \times 6.0 \times 10^{6})}$ 1 mark

$= 1.2 \times 10^{-10}$ m 1 mark

d. **observable/possible** 1 mark

Both correct terms must be circled to be awarded mark.

Question 24 (2 marks)

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

$= \frac{6.63 \times 10^{-34}}{30 \times 10^{-9}}$ 1 mark

$= 2.21 \times 10^{-26}$ N s 1 mark

Question 25 (2 marks)

A, **B**, **C** and **D** are all correct. 2 marks

Award 1 mark if only two or three answers are given.

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

Detailed study 1 – Einstein's special relativity

Question 1 **B**

A frame of reference that is described as non-inertial undergoes an acceleration relative to an inertial frame of reference.

Question 2 **A**

The Michelson–Morley experiment did not show a difference in the speed of light when light travels tangentially along the same path as the Earth through space, or when light travels perpendicular to the motion of the Earth through space.

Question 3 **A**

$$\gamma = \frac{1}{\left(\frac{1 - v^2}{c^2}\right)^{\frac{1}{2}}}$$

$$= \frac{1}{\left(\frac{1}{(1 - 0.8^2)^{\frac{1}{2}}}\right)}$$

$$= \frac{1}{0.6}$$

$$= 1.67$$

Question 4 **D**

Proper length can only be measured by the frame at rest relative to the length being measured.

Question 5 **B**

$$\text{measured length} = \text{proper length} \times \left(\frac{1 - v^2}{c^2}\right)^{\frac{1}{2}}$$

$$= 100 \times (1 - 0.62)^{\frac{1}{2}}$$

$$= 100 \times 0.8$$

$$= 80 \text{ m}$$

Question 6 **B**

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$
$$= \frac{2 \times 70}{3 \times 10^8}$$
$$= 4.67 \times 10^{-7} \text{ s}$$
$$= 467 \text{ ns}$$

Question 7 **D**

$$\text{measured time} = \frac{\text{proper time}}{\left(\frac{1 - v^2}{c^2}\right)^{\frac{1}{2}}}$$
$$= \frac{300}{(1 - 0.6^2)^{\frac{1}{2}}}$$
$$= \frac{300}{0.8}$$
$$= 375 \text{ ns}$$

Question 8 **B**

The speed of light of the signal reflected from each craft is constant as measured by Mission Control, and so for the same distance the signals will arrive at the same time.

Question 9 **B**

In its inertial frame, the proton's energy is its rest energy:

$$E = m_0c^2$$
$$= 1.67 \times 10^{-27} \times (3 \times 10^8)^2$$
$$= 1.5 \times 10^{-10} \text{ J}$$

Question 10 **D**

$$\text{kinetic energy} = \text{total energy} - \text{rest energy}$$
$$= 3.45 \times 10^{-10} - 1.5 \times 10^{-10}$$
$$= 1.95 \times 10^{-10} \text{ J}$$

Question 11 **B**

$$\text{total energy} = \text{Lorentz factor} \times \text{rest energy}$$

$$= \frac{\text{rest energy}}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$$

$$\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}} = \frac{1.95 \times 10^{-10}}{3.45 \times 10^{-10}}$$

$$\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}} = 0.436$$

$$\left(1 - \frac{v^2}{c^2}\right) = 0.436^2$$

$$\left(1 - \frac{v^2}{c^2}\right) = 0.190$$

$$\frac{v^2}{c^2} = 0.810$$

$$v = 0.90c$$

Detailed study 2 – Materials and their use in structures

Question 1 D

This comes from the gradient of the stress-versus-strain graph for glass:

$$\frac{300 \times 10^{6}}{1.0 \times 10^{-3}} = 3.0 \times 10^{11}\ \text{N m}^{-2}$$

Question 2 B

The steel is tougher than the glass. This can be determined by looking at the area under the graph for both materials. Steel can absorb a lot more energy per unit volume before it fails.

Question 3 C

One 'square' under the stress-versus-strain graph represents:

$(100 \times 10^{6})(1.0 \times 10^{-3}) = 1.0 \times 10^{5}\ \text{J m}^{-3}$.

The area under the stress-versus-strain for graph Q represents approximately 7.0 'squares' (0.7 MJ m^{-3}).

Question 4 A

Concrete is weaker under tension than compression. Therefore any reinforcing material has to be stronger in tension than concrete.

Question 5 C

The concrete beam will have its self-load and any external load causing the bottom of the beam to be under tension. Therefore the steel reinforcement needs to be placed near the bottom of the beam.

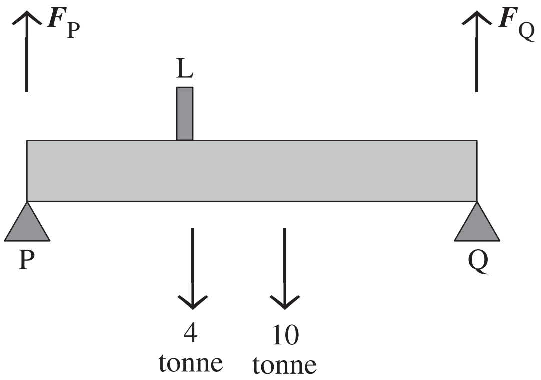
Question 6 C

The total weight (W) of the bridge and the load is given by:

$$\begin{aligned} mg &= 14\ \text{tonne} \times g \\ &= 1.4 \times 10^{5}\ \text{N} \end{aligned}$$

Question 7 **D**

The forces acting on the concrete beam are as shown below (note the arrows are **not** to scale).



Taking moments about Q gives the following equation:

$$\text{clockwise moment} = \boldsymbol{F}_P \times 10 \text{ m} = \text{anticlockwise moments}$$

$$= 10 \times 10^4 \text{ N} \times 5 \text{ m} + 4 \times 10^4 \text{ N} \times 6 \text{ m}$$

$$\boldsymbol{F}_P = 7.4 \times 10^4 \text{ N}$$

Question 8 **D**

The whole system is in equilibrium. The tension in the wire P ($\boldsymbol{T}_P$) and the tension in the wire Q ($\boldsymbol{T}_Q$) can be determined by solving the following resolution of forces equations:

Vertical forces: $\boldsymbol{T}_P \cos45° + \boldsymbol{T}_Q \cos60° = 200$ N

Horizontal forces: $\boldsymbol{T}_P \sin45° = \boldsymbol{T}_Q \sin60°$

Substitution gives $\boldsymbol{T}_P = 179$ N.

Question 9 **C**

Horizontal forces are in equilibrium:

$$\boldsymbol{T}_P \sin 45° = \boldsymbol{T}_Q \sin 60°$$

$$\boldsymbol{T}_P = \boldsymbol{T}_Q \left(\frac{\sin 60°}{\sin 45°}\right)$$

$$= (1.22)\boldsymbol{T}_Q$$

Question 10 **D**

Scissors cut by applying a shear force to the paper.

Question 11 C

$$Y = \frac{\sigma}{\varepsilon}$$
$$= \frac{F}{A\varepsilon}$$
$$= \frac{(2 \times 10^3)}{(3.14 \times 10^{-4})(0.001)}$$
$$= 6.4 \times 10^9$$
$$= 6.4 \text{ GPa}$$

Detailed study 4 – Synchrotron and its applications

Question 1 B

20 keV = 3.2×10^{-15} J

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

$$\frac{1}{2}mv^2 = 3.2 \times 10^{-15}\text{ J}$$

$$v = \sqrt{\frac{(2)(3.2 \times 10^{-15})}{9.1 \times 10^{-31}}}$$

$$= 8.4 \times 10^7\text{ m s}^{-1}$$

Question 2 A

An electron beam travelling to the right is equivalent to a conventional current travelling to the left. Use the right-hand slap rule or the left-hand FBI rule to determine that the electron beam will deflect up.

Question 3 C

$$F = qvB$$

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

$$= 6.4 \times 10^{-12}\text{ N}$$

Question 4 D

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

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

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

$$= \frac{mv}{qB}$$

$$= \frac{(9.1 \times 10^{-31})(2.0 \times 10^7)}{(1.6 \times 10^{-19})(2.0)}$$

$$= 5.7 \times 10^{-5}\text{ m}$$

Question 5 C

The function of the curved sections of the booster ring in the synchrotron is to guide the particles around the booster ring.

Question 6 D

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

Question 7 **A**

The main principle behind the use of X-rays to investigate the structure of matter in crystals is diffraction. Crystals may be considered as a series of orderly layers. The X-rays scattered off the different layers create a diffraction pattern.

Question 8 **C**

$$\begin{aligned} E &= hf \\ &= \frac{hc}{\lambda} \\ &= \frac{(4.14 \times 10^{-15})(3.0 \times 10^{8})}{8.0 \times 10^{-10}} \\ &= 1552.5 \text{ eV} \end{aligned}$$

$$\begin{aligned} E_{\text{k}} &= E_{\text{photon}} - W \\ &= 1552.5 - 4.7 \\ &= 1547.8 \text{ eV} \\ &\approx 1548 \text{ eV} \end{aligned}$$

Question 9 **A**

$$\begin{aligned} \Delta E &= \frac{hc}{\lambda_1} - \frac{hc}{\lambda_2} \\ &= (6.63 \times 10^{-34})(3.0 \times 10^{8})\left(\frac{1}{8.4 \times 10^{-10}} - \frac{1}{9.8 \times 10^{-10}}\right) \\ &= 3.4 \times 10^{-17} \text{ J} \end{aligned}$$

Question 10 **B**

Compton scattering is associated with this type of experiment.

Question 11 **C**

$$\begin{aligned} n\lambda &= 2d\sin\theta \\ \sin\theta &= \frac{n\lambda}{2d} \\ &= \frac{2(3 \times 10^{-10})}{2(4.5 \times 10^{-10})} \\ \theta &= 42° \end{aligned}$$

Detailed study 6 – Sound

Question 1 B

$$\text{frequency} = \frac{\text{speed}}{\text{wavelength}}$$
$$= \frac{340}{0.36}$$
$$= 944 \text{ Hz}$$

Question 2 C

This is found by translating the original graph to the right by $\frac{3}{4}$ of a cycle.

Question 3 A

$$I = 1.0 \times 10^{-12} \times 10^{\frac{70}{10}}$$
$$= 1.0 \times 10^{-5} \text{ W m}^{-2}$$

Question 4 C

At 1.0 m, $I = 1.0 \times 10^{-5}$.

Use the inverse square law, Id^2 = constant, to find I at 4.0 m.

$$1.0 \times 10^{-5} \times 1.0^2 = I \times 4.0^2$$
$$I = 6.25 \times 10^{-7} \text{ W m}^{-2}$$

$$L = 10\log\left(\frac{6.25 \times 10^{-7}}{1.0 \times 10^{-12}}\right)$$
$$= 58 \text{ dB}$$

Question 5 C

40 dB at 3000 Hz corresponds to a point midway between the 40 phon and 50 phon curves, that is, 45 phon.

Question 6 A

Destructive interference occurs at plane A and so the intensity is zero or constant minimum.

Question 7 D

Constructive interference occurs at plane B and so the intensity varies sinusoidally with time/position; initially, the resultant intensity is zero.

Question 8 A

The pipe has length $L = \frac{7}{4}$ of a wavelength and thus:

$$L = \frac{7\lambda}{4}$$
$$= \frac{7v}{4f}$$
$$f = \frac{7v}{4L}$$
$$= \frac{7 \times 340}{4 \times 0.85}$$
$$= 700 \text{ Hz}$$

Question 9 C

$$n\text{th harmonic frequency} = \frac{nv}{2L}$$
$$= \frac{n \times 340}{2 \times 0.85}$$
$$= 200n$$
$$n = 1, 2, 3$$

Thus the lowest frequencies are 200, 400 and 600 Hz.

Question 10 D

The main purpose of the box is to prevent the sound from the rear of the coil diffracting around to the front of the speaker and interfering with the forward sound.

Question 11 D

The speaker plays both sounds with equal strength as measured at position A. The sound which diffracts the most to position B will do so according to the ratio $\frac{\text{wavelength}}{\text{door gap}}$.

The 300 Hz sound has a wavelength 10 times that of the 3000 Hz sound and the door gap is the same.