



Trial Examination 2007

VCE Physics Unit 3

Written Examination

Suggested Solutions

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SECTION A – CORE**Area of study 1 – Motion in one and two dimensions****Question 1**

initial momentum = final momentum

$$(80 \times v_{\text{Mick}}) + (55 \times -5) = 135 \times 4 \quad 1 \text{ mark}$$

$$v_{\text{Mick}} = \frac{815}{80} = 10.2 \text{ m s}^{-1} \quad 1 \text{ mark}$$

Question 2impulse = $m\Delta v$

$$\Delta v = 4 - (-5) = 9 \text{ m s}^{-1} \quad 1 \text{ mark}$$

$$\text{impulse} = 55 \times 9 = 495 \text{ N s} \quad 1 \text{ mark}$$

Question 3

Before collision:

$$\text{kinetic energy} = \frac{1}{2} \times 80 \times 10.22 + \frac{1}{2} \times 55 \times 52 = 4849 \text{ J} \quad 1 \text{ mark}$$

After collision:

$$\text{kinetic energy} = \frac{1}{2} \times 135 \times 42 = 1080 \text{ J} \quad 1 \text{ mark}$$

Since the final kinetic energy is less than the initial kinetic energy, the collision is inelastic. 1 mark*1 consequential mark for initial kinetic energy = $687.5 + 40 \times (Q11)^2$* **Question 4**At constant speed, $\Sigma F = 0$, so driving force = resistive force = 10000 N 1 mark

At 100 m, resistive force = 7000 N (from graph) so

$$\Sigma F = 10000 - 7000 = 3000 \text{ N} \quad 1 \text{ mark}$$

Question 5

area under graph = work done to overcome resistive forces

$$= 19.5 \text{ squares} \times (2000 \times 100) = 3.9 \times 10^6 \text{ J} \quad 1 \text{ mark}$$

increase in kinetic energy = total work done – work done to overcome resistive forces

$$\frac{1}{2} \times 1500 \times v^2 = 10000 \times 500 - 3.9 \times 10^6 \quad 1 \text{ mark}$$

$$v = 38 \text{ m s}^{-1} \quad 1 \text{ mark}$$

Question 6At constant speed, ΣF on skier = 0 = tension – resistive force

$$0 = 2500 - F_{\text{resistive}} \quad 1 \text{ mark}$$

$$F_{\text{resistive}} = 2500 \text{ N} \quad 1 \text{ mark}$$

Question 7

For the boat, $\Sigma F = 0 = F_{\text{driving}} - 2500 - 9000$ so $F_{\text{driving}} = 11500 \text{ N}$.

1 mark

$$v = \frac{90}{3.6} = 25 \text{ m s}^{-1}$$

1 mark

$$P_{\text{av}} = Fv = 11500 \times 25 = 2.9 \times 10^5 \text{ W}$$

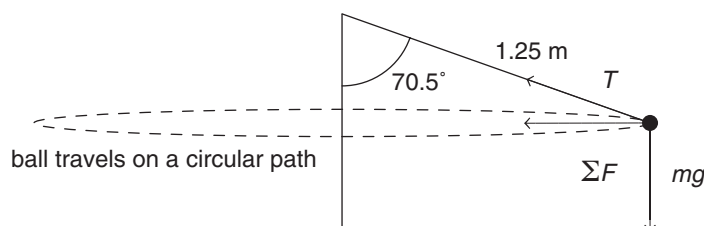
1 mark

Question 8

The skier will appear to move vertically up and down with no horizontal displacement.

1 mark

1 mark

Question 9

3 marks

*1 mark for each force correctly marked***Question 10**

To find the radius of the circular motion, $\sin 70.5^\circ = \frac{r}{1.25}$ so $r = 1.18 \text{ m}$.

1 mark

$$\Sigma F = \text{tension} \times \sin 70.5^\circ = \frac{4\pi^2 mr}{T^2}$$

$$2.4 \sin 70.5^\circ = \frac{4\pi^2 \times 0.08 \times 1.18}{T^2}$$

1 mark

$$T = 1.3 \text{ s}$$

1 mark

Question 11

$$k = \frac{200}{0.02} = 1.0 \times 10^4 \text{ N m}^{-1}$$

1 mark

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

$$\frac{1}{2} \times 0.05 \times (5.0)^2 = \frac{1}{2}(1.0 \times 10^4)x^2$$

1 mark

$$x = 0.011 \text{ m} = 1.1 \text{ cm}$$

1 mark

Question 12

Vertically:

$$u = 5 \sin 35^\circ = 2.86, v = 0, a = -9.8, x = ?$$

$$v^2 = u^2 + 2ax$$

$$0^2 = (2.86)^2 + (2 \times -9.8 \times x)$$

1 mark

$$x = 0.42 \text{ m}$$

$$\text{height above floor} = 0.42 + 0.8 = 1.22 \text{ m}$$

1 mark

Question 13

Vertically:

$$u = 5 \sin 35^\circ = 2.86, v = 0, a = -9.8, v = ?$$

$$v^2 = u^2 + 2ax$$

$$v^2 = (2.86)^2 + (2 \times -9.8 \times -0.8) \text{ so } v = 4.88 \text{ m s}^{-1}$$

1 mark

Horizontally:

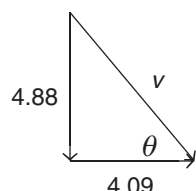
$$v = 5 \cos 35^\circ = 4.09 \text{ m s}^{-1}$$

1 mark

Magnitude of velocity:

$$v^2 = (4.88)^2 + (4.09)^2 \text{ so } v = 6.4 \text{ m s}^{-1}$$

1 mark



$$\tan \theta = \frac{4.88}{4.09}$$

$$\theta = 50^\circ$$

1 mark

Question 14

$$\frac{r_{\text{Phobos}}^3}{T_{\text{Phobos}}^2} = \frac{r_{\text{Deimos}}^3}{T_{\text{Deimos}}^2}$$

$$\frac{(9.4 \times 10^6)^3}{T_{\text{Phobos}}^2} = \frac{(2.35 \times 10^7)^3}{(30.3)^2}$$

1 mark

$$T_{\text{Phobos}} = 7.67 \text{ hr}$$

1 mark

Question 15

$$\frac{GM}{4\pi^2} = \frac{r^3}{T^2}$$

$$\frac{(6.67 \times 10^{-11})M}{4\pi^2} = \frac{(2.35 \times 10^7)^3}{(30.3 \times 60 \times 60)^2}$$

1 mark

$$\text{mass of Mars} = 6.46 \times 10^{23} \text{ kg}$$

1 mark

Question 16 D

2 marks

The area under a graph of gravitational field strength versus distance equals the change in energy for a 1 kg mass as it moves from one distance from the centre of the object producing the gravitational field to another. If the object moves towards Mars (i.e. from r_2 to r_1) it will gain kinetic energy and lose potential energy. Hence the correct answer is **D**.

Area of study 2 – Electronics and photonics**Question 1**

$$V_{\text{OUT}} = \left(\frac{R_2}{R_1 + R_2} \right) V_{\text{IN}} = \left(\frac{2.5}{4.0} \right) 20 \text{ V} \quad 1 \text{ mark}$$

$$= 12.5 \text{ V} \quad 1 \text{ mark}$$

Question 2

$$V_{\text{OUT}} = 15 \text{ V} = \left(\frac{R_2}{1.5 + R_2} \right) 20 \text{ V} \quad 1 \text{ mark}$$

$$\therefore 22.5 + 15R_2 = 20R_2$$

$$R_2 = \frac{22.5}{5} = 4.5 \text{ k}\Omega \quad 1 \text{ mark}$$

Question 3

An electro-optical converter converts electrical signals into light (electromagnetic radiation) signals. 1 mark

Question 4

The diode voltage at 40 mA = 1.5 V.

Hence the voltage drop across $R_D = 8.5 \text{ V}$ (as it is a series circuit). 1 mark

$$R_2 = \frac{8.5 \text{ V}}{0.04 \text{ A}} = 213 \text{ }\Omega \quad 1 \text{ mark}$$
Question 5

increase 1 mark

Question 6

If R_D is smaller, then I must become larger. 1 mark

Hence the LED grows brighter. 1 mark

Question 7

inverting 1 mark

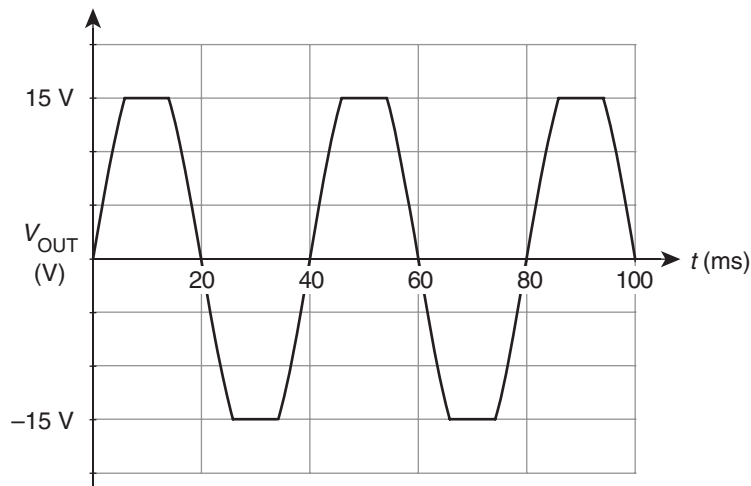
Question 8

The gradient of the graph in Figure 3 is negative. 1 mark

Question 9

$$\text{gain} = \left| \frac{V_{\text{OUT}}}{V_{\text{IN}}} \right| \quad 1 \text{ mark}$$

$$= \frac{15 \text{ V}}{5 \text{ V}} = 3 \text{ (accept } -3) \quad 1 \text{ mark}$$

Question 10

3 marks

*1 mark for correct voltage**1 mark for correct period**1 mark for correct clipping***Question 11**

$$V_{R_C} = I_C R_C = (2 \times 10^{-3})(1.8 \times 10^3) = 3.6 \text{ V}$$

1 mark

$$V_{\text{OUT}} = 10 - 3.6 = 6.4 \text{ V}$$

1 mark

Question 12

$$\begin{aligned} v_{\text{OUT}} &= i_C R_C = (1.2 \times 10^{-3})(1.8 \times 10^3) \\ &= 2.2 \text{ V} \end{aligned}$$

1 mark

Question 13

The capacitor C_{IN} blocks any DC component of the input voltage.

2 marks

Question 14

$$\begin{aligned} \text{gain} &= \left| \frac{V_{\text{OUT}}}{V_{\text{IN}}} \right| \\ &= \frac{2.2 \text{ V}}{10 \times 10^{-3} \text{ V}} \\ &= 220 \end{aligned}$$

1 mark

1 mark

SECTION B – DETAILED STUDIES**Detailed study 1 – Einstein’s special relativity****Question 1**

The Lorentz length contraction is the shortening of an object in its direction of motion when measured from a reference frame in motion relative to the object.

1 mark

1 mark

Question 2

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}} = 0.3 \sqrt{1 - \frac{(0.95c)^2}{c^2}}$$

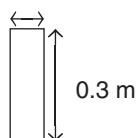
$$= 0.09 \text{ m}$$

1 mark

1 mark

Question 3

0.09 m



1 mark

Question 4

The mass of a moving electron increases as its velocity relative to the observer increases.

1 mark

1 mark

Question 5

$$\Delta E = 2.0 \text{ GeV}$$

$$\Delta m = \frac{\Delta E}{c^2} = \frac{(2.0 \times 10^9)(1.6 \times 10^{-19})}{(3 \times 10^8)^2}$$

$$= 3.6 \times 10^{-27} \text{ kg}$$

1 mark

1 mark

Question 6

$$\frac{1}{2}mv^2 = 2.0 \text{ GeV}$$

$$v = \sqrt{\frac{2 \times (2.0 \times 10^9)(1.6 \times 10^{-19})}{9.1 \times 10^{-31}}}$$

$$= 2.7 \times 10^{10} \text{ m s}^{-1}$$

1 mark

1 mark

Question 7

This is much faster than c , the speed of light.
Hence, according to Einstein’s relativity, it is not possible.

1 mark

1 mark

Question 8

The aether was the medium through which light was thought to travel.
It was believed to permeate all of space.

1 mark

1 mark

Question 9

Michelson and Morley expected to see a shift in the interference pattern produced by light waves travelling parallel and perpendicular to the aether wind.

1 mark

1 mark

Question 10

No change was observed in the interference pattern.

1 mark

This was a null result.

1 mark

Question 11

The result demonstrated that there was no evidence for the concept of the aether.

1 mark

Light can travel through space that is entirely empty.

1 mark

Question 12

$$\begin{aligned}\gamma &= \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \\ &= \frac{1}{\sqrt{1 - \frac{(0.999995c)^2}{c^2}}} \\ &= 316.2\end{aligned}$$

1 mark

1 mark

Question 13

$$\text{kinetic energy} = mc^2 - m_0c^2 = m_0c^2(\gamma - 1)$$

$$\text{kinetic energy} = (1.67 \times 10^{-27}) \times (9 \times 10^{16})(315)$$

1 mark

$$= 4.7 \times 10^{-8} \text{ J}$$

1 mark

Detailed study 2 – Investigating materials and their use in structures**Question 1**

Stiffness is given by Young's modulus, which is the gradient of the graph of stress versus strain.

1 mark

The HMPE graph has a steeper gradient than the nylon graph, so it is stiffer.

1 mark

Question 2 B

2 marks

The area under the HMPE graph is greater, so HMPE is tougher than nylon and **A** is incorrect.

HMPE withstands a greater stress before breaking, so HMPE is stronger than nylon and **B** is correct.

A stronger material will be harder to break, so **C** is incorrect.

The graph does not provide information about flexibility, so **D** is incorrect.

Question 3

$$\text{stress} = \frac{F}{A} = \frac{100 \times 10}{\pi \times (0.002)^2} = 8.0 \times 10^7 \text{ N m}^{-2}$$

1 mark

From the graph, at this stress the strain is equal to 0.4% = 0.004.

1 mark

$$\text{strain} = \frac{\Delta l}{l}$$

$$\therefore \Delta l = 0.004 \times 3.0 = 0.012 \text{ m}$$

1 mark

Question 4

The stress for this load falls within the linear region of the stress–strain graph for HMPE.

1 mark

This means that the material will behave elastically and will not be permanently deformed.

1 mark

Question 5

The maximum force that nylon can withstand = maximum stress $\times$ area

$$= (7.2 \times 10^7) \times (\pi \times (0.0025)^2) = 1414 \text{ N}$$

1 mark



tension in fishing line, T

weight of shark, mg

$$\Sigma F = ma = T - mg$$

$$100a = 1414 - 1000$$

1 mark

$$a = 4.13 \text{ m s}^{-2}$$

1 mark

Question 6

area under graph = energy per unit volume

$$1 \text{ square} = 0.01 \times 10 \times 10^7 = 10^6 \text{ J m}^{-3}$$

1 mark

$$\text{area under graph} = 3 \text{ squares} \times (10^6) = 3.0 \times 10^6 \text{ J m}^{-3}$$

1 mark

$$\text{energy} = \text{area under graph} \times \text{volume} = (3.0 \times 10^6) \times 1.5 \times (\pi \times (0.0025)^2)$$

1 mark

$$\text{energy} = 88 \text{ J}$$

1 mark

Question 7

tension

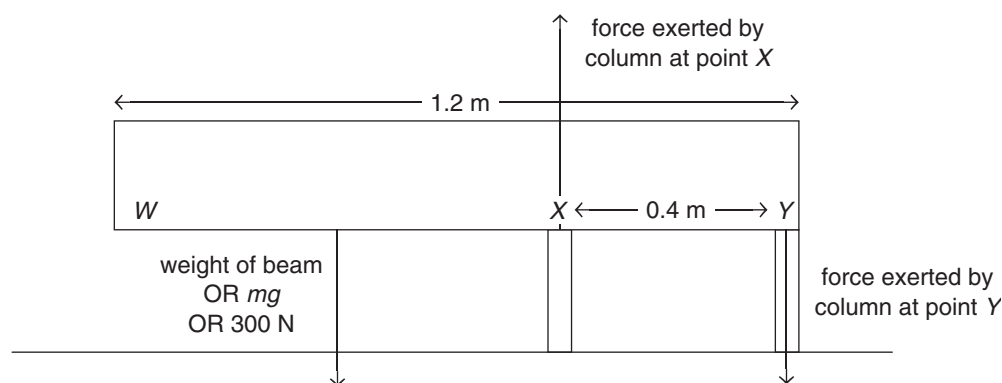
1 mark

The tensile strength of concrete is smaller than its compressive strength.

Regions A and D

1 mark

These are the regions where tension occurs in this structure.

Question 8

2 marks

1 mark for all three forces identified and in the correct location
1 mark for the direction of all forces correct

Question 9

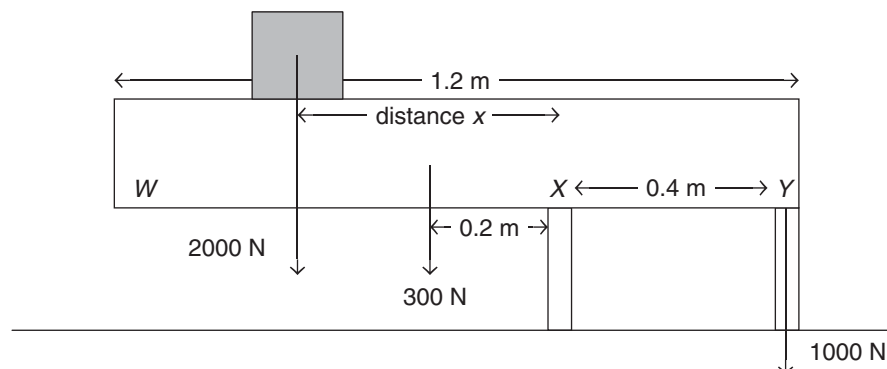
Take torque about point Y.

$$0.4F_x = 0.6(30 \times 10)$$

1 mark

$$F_x = 450 \text{ N}$$

1 mark

Question 10

Take torque about point X.

$$(300 \times 0.2) + (2000 \times x) = 0.4 \times 1000$$

1 mark

$$2000x = 340, \text{ so } x = 0.17 \text{ m}$$

1 mark

$$\text{distance from point W} = 0.8 - 0.17 = 0.63 \text{ m}$$

1 mark

Detailed study 3 – Further electronics**Question 1**

$$T = 20 \text{ ms}$$

$$f = \frac{1}{T} = \frac{1}{2 \times 10^{-2}}$$

1 mark

$$= 50 \text{ Hz}$$

1 mark

Question 2

$$V_{\text{RMS}} = \frac{V_P}{\sqrt{2}} = \frac{20}{\sqrt{2}}$$

1 mark

$$= 14.1 \text{ V}$$

1 mark

Question 3

$$\frac{N_P}{N_S} = \frac{V_{\text{IN PEAK}}}{V_{\text{OUT PEAK}}} = \frac{240\sqrt{2}}{4}$$

1 mark

$$= 85 : 1$$

1 mark

Question 4

$$P = IV$$

$$\therefore I = \frac{0.24}{240}$$

1 mark

$$= 1 \times 10^{-3} = 1.0 \text{ mA}$$

1 mark

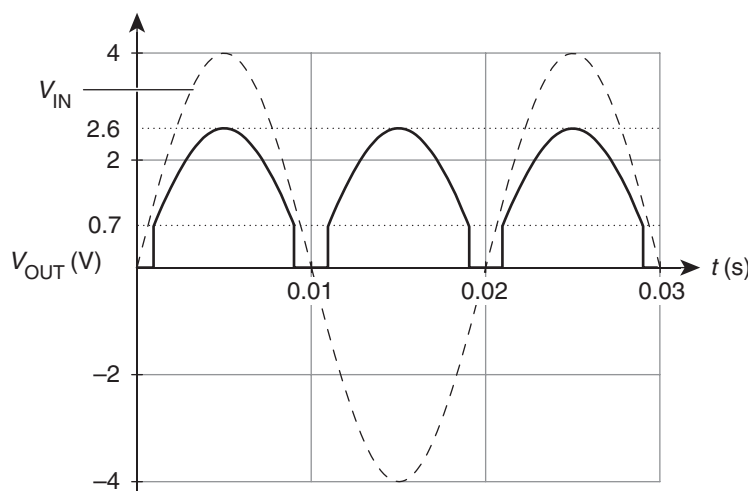
Question 5

$$\frac{I_S}{I_P} = \frac{N_P}{N_S} \Rightarrow I_S = 1.0 \text{ mA} \times 85$$

1 mark

$$= 85 \text{ mA}$$

1 mark

Question 6

3 marks

1 mark for 2.6 V peak value
2 marks for full-wave rectification

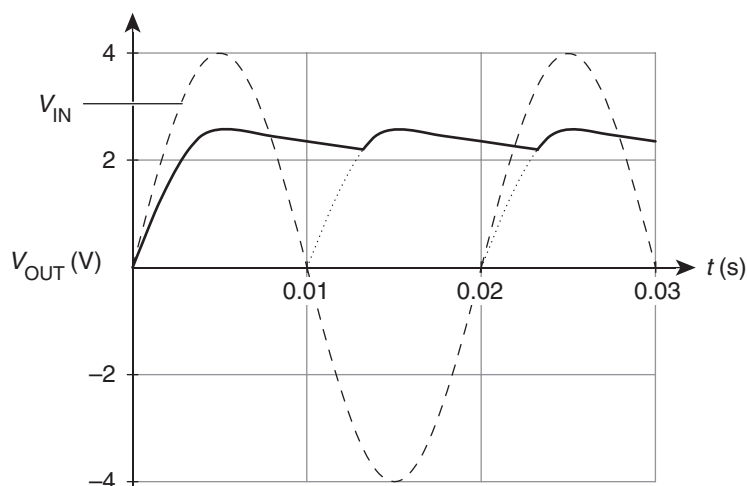
Question 7

$$\tau = RC$$

1 mark

$$= 2 \times 10^4 \times 10 \times 10^{-6} = 0.2 \text{ s}$$

1 mark

Question 8

2 marks

*2 marks for correct ripple***Question 9** **B and D**

2 marks

Since $\tau = RC$, an increase in R , C or both will create a larger time constant and therefore a smoother output.

*1 mark for B and no other answers**1 mark for D and no other answers**2 marks for B and D and no other answers***Question 10**

$$V = IR$$

$$R = \frac{9.0 \text{ V}}{300 \text{ mA}}$$

1 mark

$$= 30 \, \Omega$$

1 mark

Question 11

Certain kinds of circuit (e.g. DVD players) need voltage regulators to ensure a constant voltage that allows for consistent amplification levels and motor speeds.

1 mark

1 mark

Question 12

The performance of voltage regulators is compromised when the regulator's temperature becomes too high.

1 mark

1 mark