Neap:

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

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

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

Question 2

impulse = $m\Delta v$

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

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

Question 3

Before collision:

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

After collision:

kinetic energy = $\dfrac{1}{2} \times 135 \times 42 = 1080 \text{ J}$ 1 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

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

Question 5

area under graph = work done to overcome resistive forces

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

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

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

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

Question 6

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

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

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

Question 7

For the boat, $\Sigma F = 0 = F_{\text{driving}} - 2500 - 9000$ so $F_{\text{driving}} = 11500$ N. 1 mark

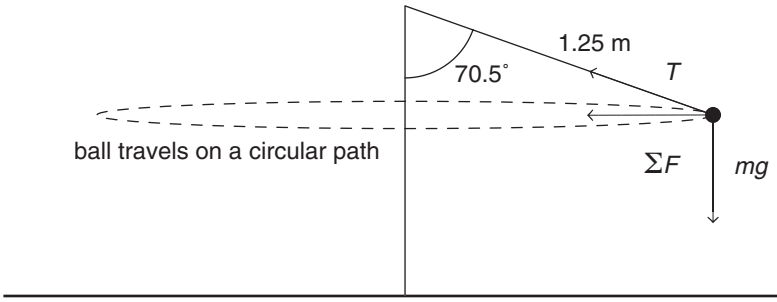
$v = \dfrac{90}{3.6} = 25 \text{ m s}^{-1}$ 1 mark

$P_{\text{av}} = Fv = 11500 \times 25 = 2.9 \times 10^5 \text{ W}$ 1 mark

Question 8

The skier will appear to move vertically up and down 1 mark
with no horizontal displacement. 1 mark

Question 9



3 marks

1 mark for each force correctly marked

Question 10

To find the radius of the circular motion, $\sin 70.5° = \dfrac{r}{1.25}$ so $r = 1.18$ m. 1 mark

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

$2.4 \sin 70.5° = \dfrac{4\pi^2 \times 0.08 \times 1.18}{T^2}$ 1 mark

$T = 1.3$ s 1 mark

Question 11

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

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

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

$x = 0.011 \text{ m} = 1.1 \text{ cm}$ 1 mark

Question 12

Vertically:

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

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

$0^2 = (2.86)^2 + (2 \times -9.8 \times x)$ 1 mark

$x = 0.42$ m

height above floor = 0.42 + 0.8 = 1.22 m 1 mark

Question 13

Vertically:

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

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

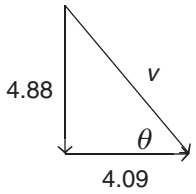
$v^2 = (2.86)^2 + (2 \times -9.8 \times -0.8)$ so $v = 4.88$ m s^{-1} 1 mark

Horizontally:

$v = 5\cos 35° = 4.09$ m s^{-1} 1 mark

Magnitude of velocity:

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



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

$\theta = 50°$ 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

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

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

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

$= 12.5 \text{ V}$ 1 mark

Question 2

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

$\therefore 22.5 + 15R_2 = 20R_2$

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

Question 3

An electro-optical converter converts electrical signals 1 mark
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

$$R_2 = \frac{8.5 \text{ V}}{0.04 \text{ A}} = 213 \ \Omega$$ 1 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

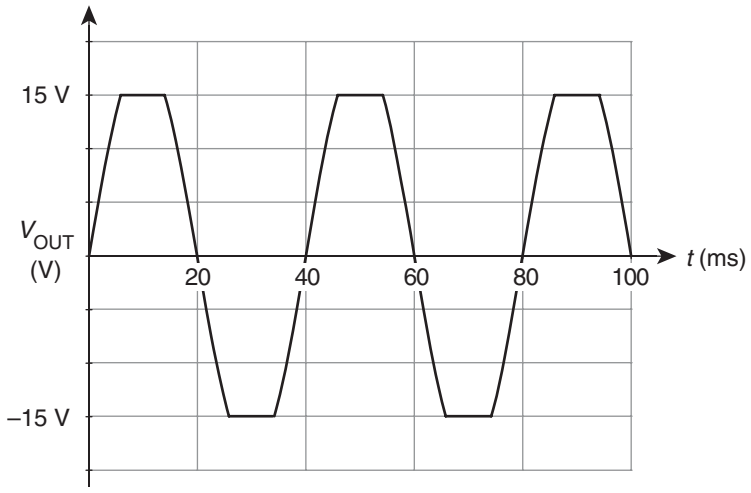
The gradient of the graph in Figure 3 is negative. 1 mark

Question 9

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

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

Question 10



3 marks
1 mark for correct voltage
1 mark for correct period
1 mark for correct clipping

Question 11

$V_{R_C} = I_C R_C = (2 \times 10^{-3})(1.8 \times 10^3) = 3.6$ V — 1 mark

$V_{OUT} = 10 - 3.6 = 6.4$ V — 1 mark

Question 12

$v_{OUT} = i_C R_C = (1.2 \times 10^{-3})(1.8 \times 10^3)$

$= 2.2$ V — 1 mark

Question 13

The capacitor C_{IN} blocks any DC component of the input voltage. — 2 marks

Question 14

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

$= \frac{2.2 \text{ V}}{10 \times 10^{-3} \text{ V}}$

$= 220$ — 1 mark

SECTION B – DETAILED STUDIES

Detailed study 1 – Einstein's special relativity

Question 1

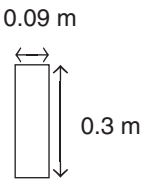
The Lorentz length contraction is the shortening of an object in its direction of motion 1 mark
when measured from a reference frame in motion relative to the object. 1 mark

Question 2

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

$= 0.09$ m 1 mark

Question 3



1 mark

Question 4

The mass of a moving electron increases 1 mark
as its velocity relative to the observer increases. 1 mark

Question 5

$\Delta E = 2.0$ GeV

$$\Delta m = \frac{\Delta E}{c^2} = \frac{(2.0 \times 10^9)(1.6 \times 10^{-19})}{(3 \times 10^8)^2}$$ 1 mark

$= 3.6 \times 10^{-27}$ kg 1 mark

Question 6

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

$$v = \sqrt{\frac{2 \times (2.0 \times 10^9)(1.6 \times 10^{-19})}{9.1 \times 10^{-31}}}$$ 1 mark

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

Question 7

This is much faster than c, the speed of light. 1 mark
Hence, according to Einstein's relativity, it is not possible. 1 mark

Question 8

The aether was the medium through which light was thought to travel. 1 mark
It was believed to permeate all of space. 1 mark

Question 9

Michelson and Morley expected to see a shift in the interference pattern 1 mark
produced by light waves travelling parallel and perpendicular to the aether wind. 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

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

$$= \frac{1}{\sqrt{1 - \frac{(0.999995c)^2}{c^2}}}$$ 1 mark

$$= 316.2$$ 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

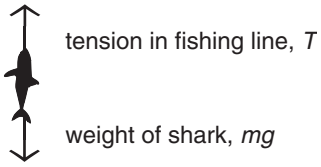
Question 4

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 × area

$= (7.2 \times 10^7) \times (\pi \times (0.0025)^2) = 1414$ N 1 mark



$\Sigma F = ma = T - mg$

$100a = 1414 - 1000$ 1 mark

$a = 4.13$ m s^{-2} 1 mark

Question 6

area under graph = energy per unit volume

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

area under graph = 3 squares × $(10^6) = 3.0 \times 10^6$ J m^{-3} 1 mark

energy = area under graph × volume = $(3.0 \times 10^6) \times 1.5 \times (\pi \times (0.0025)^2)$ 1 mark

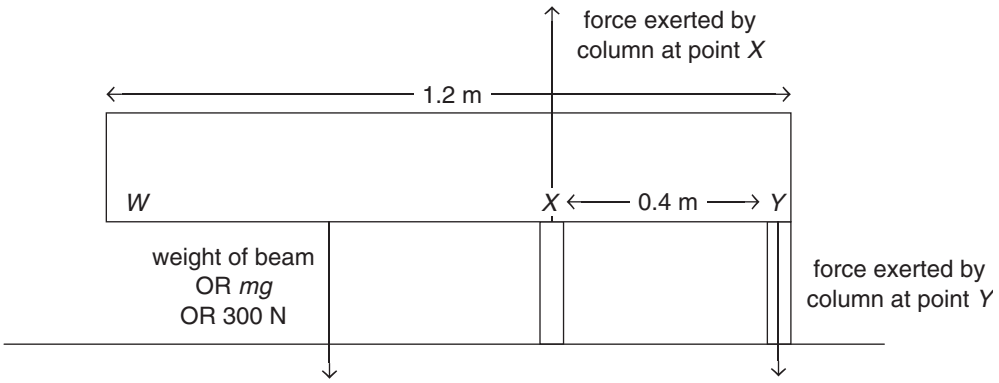
energy = 88 J 1 mark

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

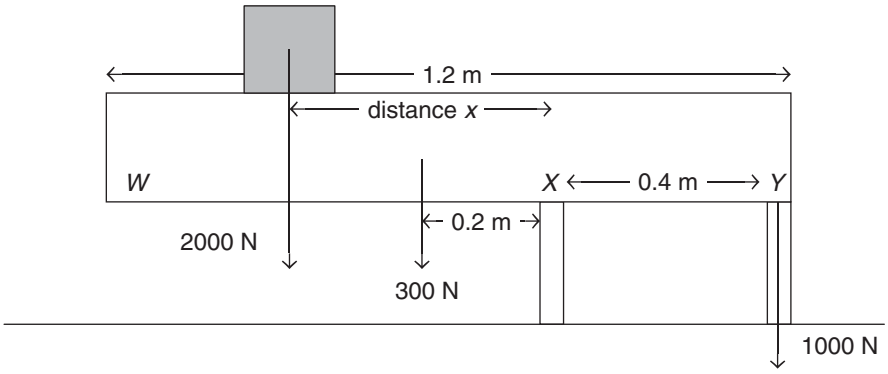
Question 9

Take torque about point *Y*.

$0.4F_x = 0.6(30 \times 10)$ 1 mark

$F_x = 450$ N 1 mark

Question 10



Take torque about point *X*.

$(300 \times 0.2) + (2000 \times x) = 0.4 \times 1000$ 1 mark

$2000x = 340$, so $x = 0.17$ m 1 mark

distance from point $W = 0.8 - 0.17 = 0.63$ m 1 mark

Detailed study 3 – Further electronics

Question 1

$T = 20$ ms

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

$= 50$ Hz 1 mark

Question 2

$V_{RMS} = \frac{V_P}{\sqrt{2}} = \frac{20}{\sqrt{2}}$ 1 mark

$= 14.1$ V 1 mark

Question 3

$\frac{N_P}{N_S} = \frac{V_{IN\ PEAK}}{V_{OUT\ PEAK}} = \frac{240\sqrt{2}}{4}$ 1 mark

$= 85 : 1$ 1 mark

Question 4

$P = IV$

$\therefore I = \dfrac{0.24}{240}$ 1 mark

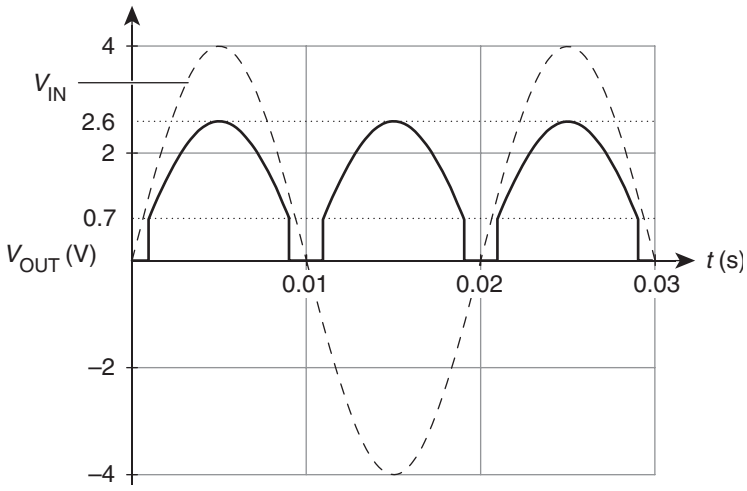
$= 1 \times 10^{-3} = 1.0$ mA 1 mark

Question 5

$\dfrac{I_S}{I_P} = \dfrac{N_P}{N_S} \Rightarrow I_S = 1.0 \text{ mA} \times 85$ 1 mark

$= 85$ mA 1 mark

Question 6



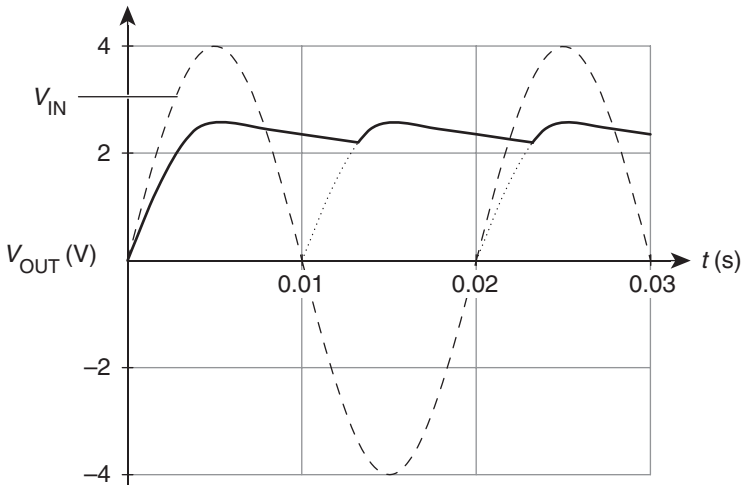
3 marks
1 mark for 2.6 V peak value
2 marks for full-wave rectification

Question 7

$\tau = RC$ 1 mark

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

$V = IR$

$R = \dfrac{9.0 \text{ V}}{300 \text{ mA}}$ 1 mark

$= 30\ \Omega$ 1 mark

Question 11

Certain kinds of circuit (e.g. DVD players) need voltage regulators to ensure a constant voltage 1 mark
that allows for consistent amplification levels and motor speeds. 1 mark

Question 12

The performance of voltage regulators is compromised 1 mark
when the regulator's temperature becomes too high. 1 mark