Neap:

Trial Examination 2014

VCE Physics Units 3&4

Written Examination

Suggested Solutions

SECTION A – CORE

Area of study – Motion in one and two dimensions

Question 1 (10 marks)

a. $v_v = 12\sin 60°$

$= 10.4 \text{ m s}^{-1}$ 1 mark

b. $t_{air} = 2 \times t_{top}$

$t_{top} = \dfrac{0 - 10.4}{-10} = 1.04$ 1 mark

$t_{air} = 2 \times 1.04 = 2.1$ 1 mark

*Note: Consequential on part **a.***

c. $s = \dfrac{1}{2}at^2$

$= \dfrac{1}{2}(10)(1.04)^2$ 1 mark

$= 5.4 \text{ m}$ 1 mark

d. Gravity is 10 m s^{-2} down

$\therefore$ 10 m s^{-2} 1 mark

e. $\text{KE} = \dfrac{1}{2}mv^2$

$v_h = 12\cos 60°$

$= 6 \text{ m s}^{-1}$ 1 mark

$\text{KE} = \dfrac{1}{2}(80)(6)^2$

$= 1440 \text{ J}$ 1 mark

f. $R = v_h t_{air}$

$= (6)(2.08)$ 1 mark

$= 12.5 \text{ m}$ 1 mark

*Note: Consequential on part **e.***

Question 2 (6 marks)

a. $\underset{\sim}{P}_{\text{before}} = (5 \times 10^3)(15) - (10 \times 10^3)(15)$

$= -7.5 \times 10^4$ kg m s^{-1}

$\underset{\sim}{V}_{\text{after}} = \dfrac{-7.5 \times 10^4}{1.5 \times 10^4}$

$= -5$ m s^{-1}

$\therefore$ 5.0 m s^{-1} LEFT — 2 marks

1 mark for magnitude
1 mark for direction

b. $\text{KE}_{\text{before}} = \frac{1}{2}(5 \times 10^3)(15)^2 + \frac{1}{2}(10 \times 10^3)(15^2)$

$= 1\ 687\ 500$ J

$\text{KE}_{\text{after}} = \frac{1}{2}(15 \times 10^3)(5)^2$

$= 187\ 500$ J — 1 mark

$\Delta\text{KE} = 1\ 500\ 000$ J

$= 1.5$ MJ — 1 mark

*Note: Consequential on part **a.***

c. It is lost as heat — 1 mark
and sound. — 1 mark

Question 3 (3 marks)

a. $\Sigma F = ma$

$30 = (2 + 4)a$

$a = 5$ m s^{-2} — 1 mark

b. Block A accelerates at 5 m s^{-2}.

$\Sigma F_{\text{A}} = 2(5) = 30 - F_{\text{B on A}}$

$= 10$ N to the right $= 30 - F_{\text{B on A}}$ — 1 mark

$\therefore F_{\text{B}} = 20$ N (to the left) — 1 mark

Question 4 (3 marks)

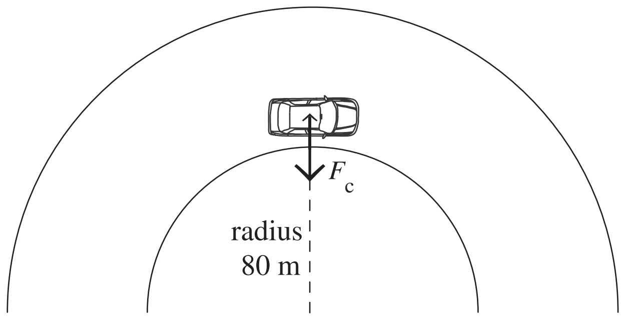
a. $F_c = \frac{mv^2}{R}$

$v = \sqrt{\frac{F_c R}{m}}$

$= \sqrt{\frac{(2800)(80)}{1400}}$ 1 mark

$= 12.6 \text{ m s}^{-1}$ 1 mark

b.



1 mark

Question 5 (3 marks)

a. $\Sigma\vec{F} = \frac{mv^2}{R}$

$T - mg = \frac{mv^2}{R}$

$T = mg + \frac{mv^2}{R}$

$= 1(10) + \frac{1(5^2)}{0.5}$ 1 mark

$= 60 \text{ N}$ 1 mark

b. 0 J 1 mark

As the force is always perpendicular to the direction of travel, no work is done.

Question 6 (3 marks)

$F\Delta t = m\Delta v$

Area under graph gives $F\Delta t$.

$F\Delta t = 400 \times 10 \times 10^{-3}$

$= 4$ 1 mark

$\Delta v = \frac{4}{60 \times 10^{-3}}$

$= 66.7 \text{ m s}^{-1}$ 1 mark

$= 240 \text{ km h}^{-1}$ 1 mark

Question 7 (4 marks)

a. $F = kx$

$k = \frac{F}{x}$

$= \frac{2000}{10}$

$= 200\ \text{N m}^{-1}$ 2 marks

1 mark for correct value
1 mark for correct unit

b. $\text{PE}_{\text{stored}} = \frac{1}{2}kx^2$

$= \frac{1}{2}(200)(8.6)^2$ 1 mark

$= 7396\ \text{J}$

$= 7.4 \times 10^3\ \text{J}$ 1 mark

*Note: Consequential on part **a.***

Question 8 (3 marks)

The trainee astronauts still have weight, as they are still in a strong gravitational field and $W = mg$. 1 mark

Weightlessness only occurs in deep space away from all masses. This does not apply here. 1 mark

Because the centripetal acceleration at the top of the circle is given exactly by gravity, they feel 'apparent weightlessness' or apparent zero-g. 1 mark

Question 9 (5 marks)

a. $R = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$ 1 mark

$= \sqrt[3]{\frac{(6.67 \times 10^{-11})(5.98 \times 10^{24})(86\,400)^2}{4\pi^2}}$ 1 mark

$= 4.2 \times 10^7\ \text{m}$ 1 mark

b. $F = mg = m\frac{GM}{R^2}$

$= \frac{(1432)(6.67 \times 10^{-11})(5.98 \times 10^{24})}{(4.2 \times 10^7)^2}$ 1 mark

$= 3.24 \times 10^2\ \text{N}$ 1 mark

*Note: Consequential on part **a.***
Subtract one mark if answer not given to three significant figures.

Area of study – Electronics and photonics

Question 10 (12 marks)

a. From graph, at 25°, $R_{TDR} = 500\ \Omega$ 1 mark

$$\frac{V_{OUT}}{V_{IN}} = \frac{R_2}{R_1 + R_2}$$

$$\frac{4}{9} = \frac{500}{R_1 + 500}$$ 1 mark

$$R_1 = 625\ \Omega$$ 1 mark

b. $P = \dfrac{V^2}{R}$

$= \dfrac{4^2}{500}$ 1 mark

$= 3.2 \times 10^{-2}$ W 1 mark

c. $P_{TDR} = VI$

$3.2 \times 10^{-2} = 4 \times I$

$I = 8.0 \times 10^{-3}$ A 1 mark

$V_{\text{variable resistor}} = 9.0 - 4.0 - 1.4 = 3.6$ V

$R_{\text{variable resistor}} = \dfrac{V}{I} = \dfrac{3.6}{8.0 \times 10^{-3}} = 450\ \Omega$ 1 mark

Hence the value of the variable resistor must decrease. 1 mark

d. As temperature decreases, the resistance of thermistor increases, so V_{OUT} increases. 1 mark

When the temperature DECREASES this would turn ON a device connected in parallel with the thermistor 1 mark
so could control the heater. 1 mark

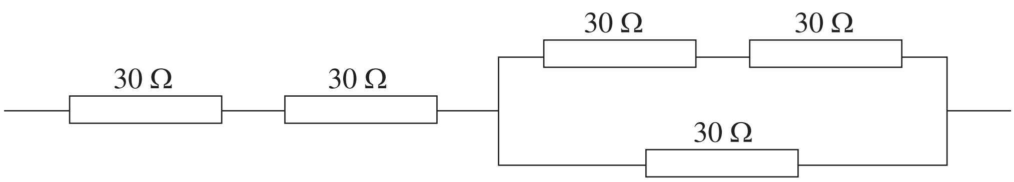
OR

When the temperature DECREASES it could turn OFF a device connected in parallel with the variable resistor 1 mark
so could control an air conditioner. 1 mark

e. The LED is an opto-electrical device. 1 mark

As the current through the LED increases, its brightness will also increase, so the LED converts electrical energy to light energy. 1 mark

Question 11 (2 marks)



2 marks

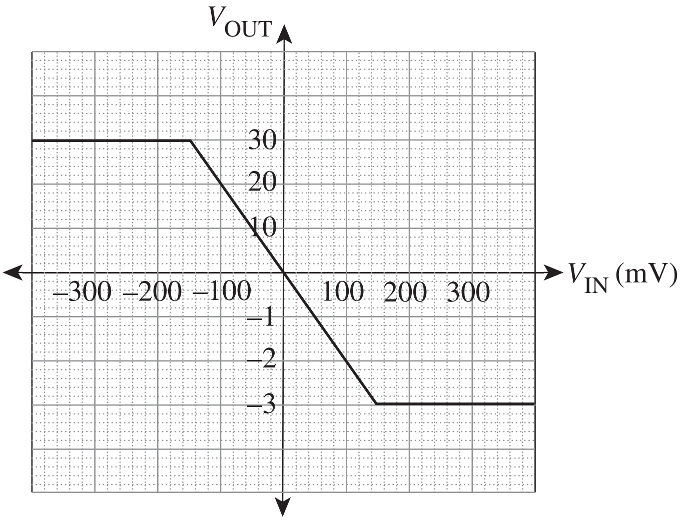
Question 12 (5 marks)

a. When V_{IN} = 150 mV, V_{OUT} = –30 V

magnitude of gain $= \frac{30}{0.15}$ — 1 mark

$= 200$ — 1 mark

b.



3 marks

1 mark for correct scale

1 mark for clipping region shown

1 mark for inverted (negative gradient)

Question 13 (4 marks)

Position	*P*	*Q*	*R*	*S*
Waveform (**A**, **B**, **C** or **D**)	**C**	**A**	**D**	**C**

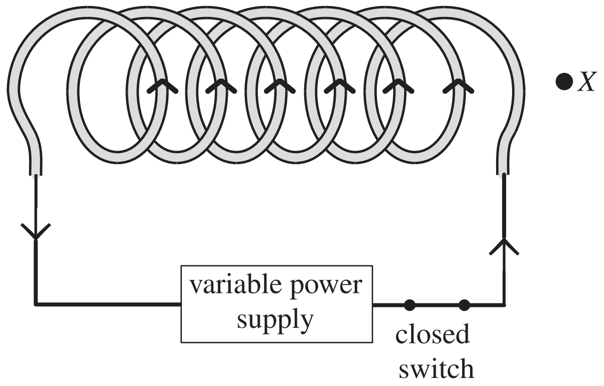
4 marks

1 mark for each correct answer

Area of study – Electric power

Question 14 (7 marks)

a.



1 mark

If the north pole is repelled then there must be an induced north pole at the left-hand end of the coil. 1 mark

Use the right-hand grip rule to predict the current flow. 1 mark

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

Looking from *X*, the current is flowing in a clockwise direction. Using the right-hand grip rule, this means the induced field is into the page.

*Note: Consequential on part **a.***

c. current direction: from *B* to *A* 1 mark

As the south pole approaches, the induced field will oppose the increasing flux. 1 mark

Using the right-hand grip rule this will mean the current flows downwards in the coil and from *B* to *A* in the galvanometer. 1 mark

Question 15 (16 marks)

a. $F = NBIl = 30 \times 0.35 \times 2.5 \times 0.1$ 1 mark

$= 2.6$ N 1 mark

b. There will be no force (NF written next to side *XY*) as the current is parallel to the field. 1 mark

c. The force on side *YZ* is out of the page so side *YZ* would initially move upwards. 1 mark

When *YZ* has passed $\frac{1}{4}$ of a turn (the coil is horizontal) the force will still be out of the page, so this will cause the coil to rotate back in the opposite direction. 1 mark

The coil will oscillate around this horizontal position and eventually stop. 1 mark

d. The correct answer is **B**. 1 mark

The split-ring commutator will change the current direction in the coil each half-turn, allowing continual rotation.

e. flux $= BA$

$= 0.35 \times (0.10 \times 0.15)$ 1 mark

$= 5.3 \times 10^{-3}$ Wb 1 mark

 TEVPHYU34_SS_2014.FM

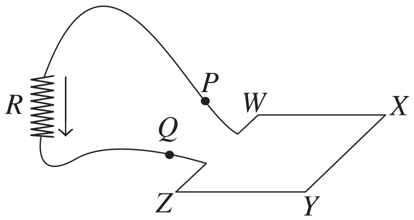
f. $\text{EMF} = \frac{N\Delta\Phi}{\Delta t}$

$0.15 = \frac{30 \times (5.3 \times 10^{-3} - 0)}{\Delta t}$ 1 mark

$\Delta t = 1.1 \text{ s}$ 1 mark

*Note: Consequential on part **e.***

g.



1 mark

The flux is upwards and decreasing. 1 mark

Lenz's law tells us that the induced field will oppose this change, i.e. it will be in the same direction (up). The right-hand grip rule predicts current will flow *ZYXW*, which means it flows down through *R*. 1 mark

h. The correct answer is **D**. 2 marks

The time from position A to B is $\frac{1}{4}$ of the time from position B to C. Hence the EMF for A to B will be four times the EMF for B to C, since $\text{EMF} = \frac{N\Delta\Phi}{\Delta t}$ and $N\Delta\Phi$ is constant.

Since $P = \frac{V^2}{R}$, the power dissipated as the coil moves from A to B will be 16 times the power dissipated as the coil moves from B to C.

Question 16 (13 marks)

a. $f = \frac{1}{T}$

$= \frac{1}{(5 \times 10^{-2})}$ 1 mark

$= 20 \text{ Hz}$ 1 mark

b. Equivalent DC voltage is $V_{\text{RMS}} = \frac{120}{\sqrt{2}}$ 1 mark

$V = 85 \text{ V}$ 1 mark

c. For the step-up transformer, $V_{IN} = 120$ V, so $V_{OUT} = 120 \times 20 = 2400$ V 1 mark

$$I = \frac{P}{V}$$

$$= \frac{500}{2400}$$

$$= 0.21 \text{ A}$$ 1 mark

$$P_{loss} = I^2R$$

$$= 0.21^2 \times (5 \times 400)$$

$$= 88 \text{ W}$$ 1 mark

d. $$V_{drop} = IR$$

$$= 0.21 \times 2000$$

$$= 420 \text{ V}$$ 1 mark

$$V_{delivered} = 2400 - 420$$

$$= 1980 \text{ V}$$ 1 mark

After the step-down transformer, $V = \frac{1980}{20} = 99$ V. 1 mark

e. The transformer needs AC to operate 1 mark
as the current in the secondary coil is induced by a changing current and magnetic flux in the primary coil. 1 mark
A DC battery will not provide this changing current so the pump will receive no power/voltage and will not operate. 1 mark

Area of study – Interactions of light and matter

Question 17 (7 marks)

a. first nodal line $\Rightarrow$ path difference = $\frac{\lambda}{2}$ — 1 mark

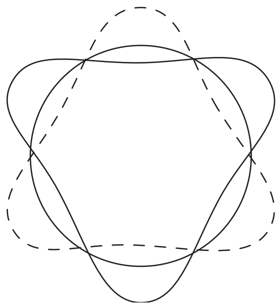
$\frac{532}{2} = 266$ nm — 1 mark

b. The lines of the pattern will be closer together and the spacing will be smaller. — 1 mark

c. As $\lambda_{RED} > \lambda_{GREEN}$, the spacing will be larger as the pattern spreads out. — 1 mark

d.
1. The interference pattern is created by constructive and destructive interference. — 1 mark
2. This is explained by the path difference between $S_1P_1 - S_2P_2$, requiring it to be reliant on a whole number of wavelengths and a whole number plus half wavelengths. — 1 mark
3. This is well-modelled by wave theory. Thus if the light has a wavelength it has wave properties. — 1 mark

Question 18 (2 marks)



1 mark

If the orbit is an exact multiple of the wavelength of the electron, a standing wave is formed. This means that electrons of those particular wavelengths can exist in the atom. Since different wavelengths correspond to specific energies, only those energy states are possible for the atom. The diagram above shows an example of exactly 3λ. — 1 mark

Question 19 (8 marks)

a. Planck's constant is given by gradient.

$h = \frac{1.8}{4.4 \times 10^{14}}$ — 1 mark

$= 4.09 \times 10^{-15}$ eVs — 2 marks

1 mark for correct value
1 mark for correct units
Subtract one mark if answer not given to three significant figures.

b. total energy of photon = 3.0 + 1.8 = 4.8 eV 1 mark

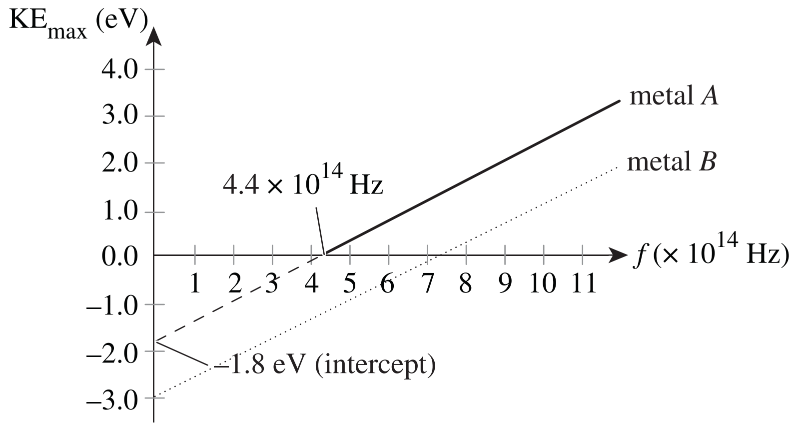
$$E = \frac{hc}{\lambda}$$

$$\lambda = \frac{(4.14 \times 10^{-15})(3 \times 10^{8})}{4.8}$$

$$= 2.56 \times 10^{-7} \text{ m}$$ 1 mark

Subtract one mark if answer not given to three significant figures.

c.



2 marks

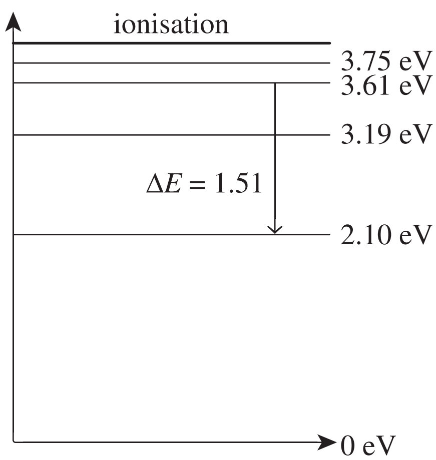
1 mark for intercept KE_{max} = –3.0 eV.

1 mark for same gradient as metal A.

(Students may dot line below KE = 0 axis.)

Question 20 (4 marks)

a. 3.61 eV – 2.10 eV = 1.51 eV photon



2 marks

b. Longest λ is the smallest energy change.

$\Delta E = 3.75 - 3.61$

$= 0.14$ eV — 1 mark

$\lambda = h\dfrac{c}{E}$

$= \dfrac{(4.14 \times 10^{-15})(3 \times 10^{8})}{0.14}$

$= 8.8 \times 10^{-6}$ m — 1 mark

Question 21 (6 marks)

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

$= \dfrac{6.63 \times 10^{-34}}{(9.11 \times 10^{-31})(6.8 \times 10^{6})}$ — 1 mark

$= 1.07 \times 10^{-10}$ m — 1 mark

b. This experiment **does** demonstrate the wave nature of electrons — 1 mark

because there will be a significant diffraction occurring as $\lambda \approx d$ (the atomic spacing). — 1 mark

c. $\lambda = \dfrac{h}{\sqrt{2(\mathrm{KE})m}}$ as $p = \sqrt{2(\mathrm{KE})m}$

$\dfrac{\lambda_{\text{neutron}}}{\lambda_{\text{electron}}} = \sqrt{\dfrac{m_{\text{e}}}{m_{\text{n}}}} = \dfrac{1}{42.8}$ — 1 mark

Thus since $\dfrac{(\lambda_{\text{neutron}} = \lambda_{\text{electron}})}{42.8}$, then $\lambda_{\text{neutron}} < \text{atomic spacing}$ and so diffraction will not be observable, therefore the answer is NO. — 1 mark

Question 22 (2 marks)

Nia is correct. — 1 mark

For electrons and X-rays to produce the same diffraction pattern they must have the same de Broglie wavelength. Since for both electrons and photons the de Broglie wavelength is given by $\lambda = \dfrac{h}{p}$, if the wavelength is the same then the momentum must be the same as well. — 1 mark

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

Detailed study 1 – Einstein's special relativity

Question 1 **B**

$$L = L_0\sqrt{1 - \frac{v^2}{c^2}}$$

$$= R_0\sqrt{1 - 0.95^2}$$

$$= 0.31\ R_0$$

Question 2 **C**

The spaceship contracts in the direction of motion.

Question 3 **B**

$$\gamma = \frac{1}{\sqrt{1 - \frac{(0.995c)^2}{c^2}}}$$

$$= 10.01$$

$$t_0 = \frac{20\text{ ns}}{10.01}$$

The particle's half-life in its reference frame is 2.0 ns.

Question 4 **C**

$$\gamma = \frac{1}{\sqrt{1 - \frac{(0.995c)^2}{c^2}}}$$

$$= 10.01$$

$$L = \frac{L_0}{10.01}$$

$$= \frac{400}{10.01}$$

$$= 40\text{ m}$$

Question 5 **B**

$(8.0 \times 10^8)(1.6 \times 10^{-19}) = 1.28 \times 10^{-10}$ J

Question 6 **A**

$$\Delta m = \frac{\Delta E}{c^2}$$

$$= \frac{(8.0 \times 10^8 \times 1.6 \times 10^{-19})}{(3.0 \times 10^8)^2}$$

$$= 1.4 \times 10^{-27} \text{ kg}$$

Question 7 **D**

The aim of Michelson and Morley's experiment was to determine the speed of the Earth through the ether.

Question 8 **B**

Michelson and Morley observed no time difference in the respective journeys of the two beams (a null result).

Question 9 **C**

The combined mass of the positron and electron creates two equally energetic gamma rays.

Therefore the energy of one gamma ray is given by

$$E = mc^2$$

$$= (9.11 \times 10^{-31})(3 \times 10^8)^2$$

$$= 8.2 \times 10^{-14} \text{ J}$$

Question 10 **B**

It is impossible to provide the infinite kinetic energy required to get the proton to the speed of light.

Question 11 **B**

The electrical properties of a medium change the medium's refractive index and hence the speed of light through that medium.

Detailed study 2 – Materials and their use in structures

Question 1 **C**

$$\begin{aligned}\text{torque} &= Fx \\ &= 0.6 \times (20 \times 10 \times \cos 40°) \\ &= 92 \text{ Nm}\end{aligned}$$

Question 2 **D**

distance from wall to strut attachment on awning = 0. 3 m (isosceles triangle)

net torque around $X = 0$

$$92 = 0.3 \times F \times \cos 10°$$

$$F = 311 \text{ N}$$

Question 3 **A**

Take torque about the point where the strut meets the awning. Since net torque equals zero, the force that the wall exerts on the awning must have a component **downwards** to balance the weight of the awning.

Since net force on the awning equals zero, the force that the wall exerts on the awning must have a component to the **right** to balance the component of the force of the strut on the awning to the left.

Hence the force exerted by the wall on the awning must have a downward and right component, i.e. option **A**.

Question 4 **B**

The strut will be in compression, the top of the awning in tension and the bottom of the awning in compression.

Question 5 **C**

$$\begin{aligned}\text{stress} &= \frac{F}{A} \\ &= \frac{200}{0.04^2} \\ &= 1.3 \times 10^5 \text{ N m}^{-2}\end{aligned}$$

Question 6 **B**

$$Y = \frac{\text{stress}}{\text{strain}}$$

$$1.0 \times 10^{10} = \frac{1.3 \times 10^5}{\text{strain}}$$

$$\text{strain} = 1.3 \times 10^5 = \frac{\Delta l}{0.3}$$

$$\Delta l = 3.8 \times 10^{-6} \text{ m}$$

Question 7 **A**

Material *W* has a linear graph both in tension and compression, indicating no plastic extension.

Question 8 **A**

energy per unit volume = area under stress–strain graph

$$\begin{aligned}\text{area} &= \text{number of squares} \times \text{area of 1 square}\\ &= 7 \times (1.0 \times 10^{-3}) \times (1.0 \times 10^{6})\\ &= 7.0 \times 10^{3}\ \text{J m}^{-3}\end{aligned}$$

Question 9 **C**

Material *Y*, like concrete, is much stronger in compression than in tension.

Question 10 **D**

Z is the strongest material in tension and is still ductile, so it would be a good material to reinforce concrete with as concrete is weak in tension.

Question 11 **A**

$$\begin{aligned}\text{stress} &= \frac{F}{A}\\ &= \frac{3.0 \times 10^{3}}{\pi \times 0.025^{2}}\\ &= 1.5 \times 10^{6}\ \text{N m}^{-2}\end{aligned}$$

$$\begin{aligned}\frac{\text{energy}}{\text{volume}} &= \text{area under graph}\\ &= \frac{1}{2} \times (1.5 \times 10^{6}) \times (1.0 \times 10^{-3})\\ &= 750\ \text{J m}^{-3}\end{aligned}$$

$$\begin{aligned}\text{energy} &= 750 \times (\pi \times 0.025^{2}) \times 0.6\\ &= 0.9\ \text{J}\end{aligned}$$

Detailed study 3 – Further electronics

Question 1 **C**

The period T of the AC voltage signal is 20 ms (as the frequency is 50 Hz and $T = \frac{1}{f}$).

Question 2 **C**

The peak voltage, V_p, of this AC signal is 339 V. ($V_p = 240\sqrt{2}$)

Question 3 **B**

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$\frac{240}{24} = \frac{10}{1}$$

The output voltage of the secondary coil is 24 V AC.

Question 4 **C**

$$\text{As } P_{IN} = P_{OUT}$$

$$(240)(0.1) = (24)(1)$$

$$I = 1.0 \text{ A}$$

Question 5 **B**

The resistor has 10 – 1.2 = 8.8 V across it.

Using $V = IR$,

$$I = \frac{8.8 \text{ V}}{200}$$

$$= 44 \text{ mA}$$

Question 6 **D**

The capacitor smooths the voltage output of the circuit.

Question 7 **B**

$$\tau = RC$$

$$= (200)(50 \times 10^{-6})$$

$$= 1 \times 10^{-2} \text{ s}$$

$$= 10 \text{ ms}$$

Question 8 **D**

The capacitor smooths the output voltage.

Question 9 **B**

$V = IR$

$9 = 0.18R$

$R = 50\ \Omega$

Question 10 **C**

Voltage regulators ensure that the voltage output is constant for a range of current values.

Question 11 **D**

Although voltage regulator heat sinks are commonly made from aluminium because it is a very good conductor, other metals can also be used.

Detailed study 4 – Synchrotron and its applications

Question 1 **C**

$$E = \frac{F}{q} = \frac{V}{d}$$

$$\frac{ma}{q} = \frac{V}{d}$$

$$V = \frac{mad}{q}$$

$$= (9.1 \times 10^{-31}) \times (8.2 \times 10^{16}) \times \frac{0.15}{(1.6 \times 10^{-19})}$$

$$= 7.0 \times 10^{4}\ \text{V}$$

Question 2 **D**

$$E = \frac{V}{d}$$

$$= \frac{7.0 \times 10^{4}}{0.15}$$

$$= 4.7 \times 10^{5}\ \text{V m}^{-1}$$

*Note: Consequential on **Question 1***

Question 3 **B**

Electrons are further accelerated in the linac and in the booster ring before they enter the storage ring, hence the electrons at plate *Y* would be slower than those in the linac and the storage ring.

Question 4 **B**

Synchrotron radiation is produced when an electron changes direction.

Question 5 **D**

$$R = \frac{mv}{Bq}$$

$$= \frac{2.3 \times 10^{-17}}{(1.6 \times 10^{-19}) \times 4.8}$$

$$= 30\ \text{m}$$

Question 6 **A**

The multipole wiggler increases the intensity and produces a broad band of incoherent light. The undulator increases intensity and results in a narrow beam of coherent light. The monochromators selects photons of a specific wavelength.

Question 7 **C**

The multipole wiggler and undulator are found in the storage ring. The monochromator will be in a beamline.

Question 8 **A**

Compton scattering is inelastic, hence the energy of the photon decreases in the collision, and hence the wavelength of the incident photon must be shorter than the wavelength of the scattered photon. Since 6.0×10^{-12} m is shorter than that of the scattered photon, this is the correct option.

Question 9 **A**

Thomson scattering is elastic so kinetic energy is conserved. In all collisions momentum is conserved.

Question 10 **C**

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

$$\lambda = (1 \times 10^{-10})\sin 7.4°$$

$$= 1.3 \times 10^{-11} \text{ m}$$

Question 11 **B**

$$3\lambda = 2d\sin\theta$$

$$3 \times (1.3 \times 10^{-11}) = 2 \times (1.0 \times 10^{-10}) \times \sin\theta$$

$$\theta = 11.2°$$

Detailed study 5 – Photonics

Question 1 A

The term incoherent when applied to an incandescent light source means that the light emitted is out of phase.

Question 2 D

Laser light is monochromatic (one wavelength) and coherent (in phase).

Question 3 C

$$c = \lambda f$$

$$\begin{aligned} f &= \frac{c}{\lambda} \\ &= \frac{3 \times 10^{8}}{5.2 \times 10^{-7}} \\ &= 5.8 \times 10^{14} \text{ Hz} \end{aligned}$$

Question 4 B

$$\begin{aligned} E &= hf \\ &= (4.14 \times 10^{-15})(5.8 \times 10^{14}) \\ &= 2.4 \text{ eV} \end{aligned}$$

Question 5 C

Light is emitted by the LED is as a result of the movement of electrons from the conduction band to the valence band of a semiconductor.

Question 6 B

Modal dispersion in optical fibres is characterised by different modes taking different paths while travelling through the optical fibre.

Question 7 D

Modal dispersion can be minimised using a graded-index fibre.

Question 8 B

An optical-fibre sensor system measures the stress forces in a plane via the modulation of the intensity of the infrared light, which can then be read at the sensor.

Question 9 C

$$\begin{aligned} \sin\theta_{\text{c}} &= \frac{1.41}{1.48} \\ \theta_{\text{c}} &= 72.3° \end{aligned}$$

 TEVPHYU34_SS_2014.FM

Question 10 B

$$\alpha = \sin^{-1}(\sqrt{1.48^2 - 1.41^2})$$
$$= 26.7°$$

Question 11 C

When placing the optical fibre in water (n = 1.33) the critical angle stays the same but the acceptance angle becomes smaller.

Detailed study 6 – Sound

Question 1 **D**

$$F = \frac{v}{\lambda}$$

$$= \frac{340}{0.068}$$

$$= 5000 \text{ Hz}$$

Question 2 **B**

$$93 = \frac{10\log_{10} I}{10^{-12}}$$

$$10^{9.3} = \frac{I}{10^{-12}}$$

$$I = 10^{-2.7}$$

$$= 2.0 \times 10^{-3} \text{ W m}^{-2}$$

Question 3 **C**

Distance is multiplied by 4, hence intensity will be $\frac{1}{2^4}$.

Each time intensity halves, the dB level decreases by 3 dB.

Since the intensity halves 4 times, the dB reading will decrease by (4 × 3) dB = 12 dB

dB at 40 m = 93 – 12 = 81 dB

Question 4 **C**

Like the dynamic microphone, the velocity microphone operates using electromagnetic effects.

Question 5 **A**

The purpose of a baffle on a speaker is to reduce the destructive interference between the out-of-phase sound waves produced by the back and front of the speaker. It does this by preventing these waves from interacting.

Question 6 **B**

In a loudspeaker the changing current in the movable coil induces a changing magnetic field. This interacts with the field of the permanent magnet, and the force on the coil from this interaction causes the speaker cone to move backwards and forwards.

Question 7 **B**

Maximum diffraction will occur when $\frac{\lambda}{d}$ is greater than 1. Hence $\lambda \geq 2.5$.

$$f \leq \frac{340}{2.5}$$

$$f \leq 136 \text{ Hz}$$

So the range 30–130 Hz is the best option. Option **A** is not feasible as the human ear cannot detect these frequencies.

Question 8 **B**

The wavelength of a standing wave is the same as the wavelength of the travelling wave that produces it.

Question 9 **C**

For a string fixed at both ends,

$$f_{\text{n}} = \frac{nv}{2l}$$

$$526 = \frac{l \times v}{2 \times 0.65}$$

$$v = 684 \text{ m s}^{-1}$$

Question 10 **A**

For a pipe closed at one end,

$$f_{\text{n}} = \frac{nv}{4l}$$

$$526 = \frac{3 \times 340}{4l}$$

$$l = 0.48 \text{ m}$$

Question 11 **B**

Options **A**, **C** and **D** are incorrect.

Since the 100 phon curve is very flat between 40 and 1000 Hz, these will all be perceived to have similar loudness.

