Trial Examination 2006

VCE Physics Unit 4

Written Examination

Suggested Solutions

SECTION A – CORE

Area of study 1 – Electric power

Question 1

$F = NBIl$

$0.15 = N \times 0.2 \times 0.1 \times 0.15$ 1 mark

$N = 50$ turns 1 mark

Question 2

Since side BC is parallel to the field direction, 1 mark
the force on side BC is equal to zero. 1 mark

Question 3 **E** 2 marks

This can be found using the right-hand slap rule, by placing the fingers in the direction of the magnetic field (pointing left), thumb in the direction of the current (upwards), and the palm representing the direction of the force (out of the page).

Question 4

The force on side CD remains in the same direction as the coil rotates beyond 90°. 1 mark

This causes the coil to change direction and rotate back in the opposite direction, 1 mark

continuing to do this about the 90° mark until it stops. 1 mark

Question 5

A commutator changes the direction of the current in the coil 1 mark

each half rotation, in order to change the direction of the force on the coil 1 mark

to ensure continuous rotation in one direction. 1 mark

Question 6

$A = 10.0 \text{ cm}^2 = 10.0 \times 10^{-4} \text{ m}^2$ 1 mark

$\Phi = BA = 0.2 \times (10.0 \times 10^{-4})$ 1 mark

$\Phi = 2.0 \times 10^{-4}$ Wb 1 mark

Question 7

Calculations:

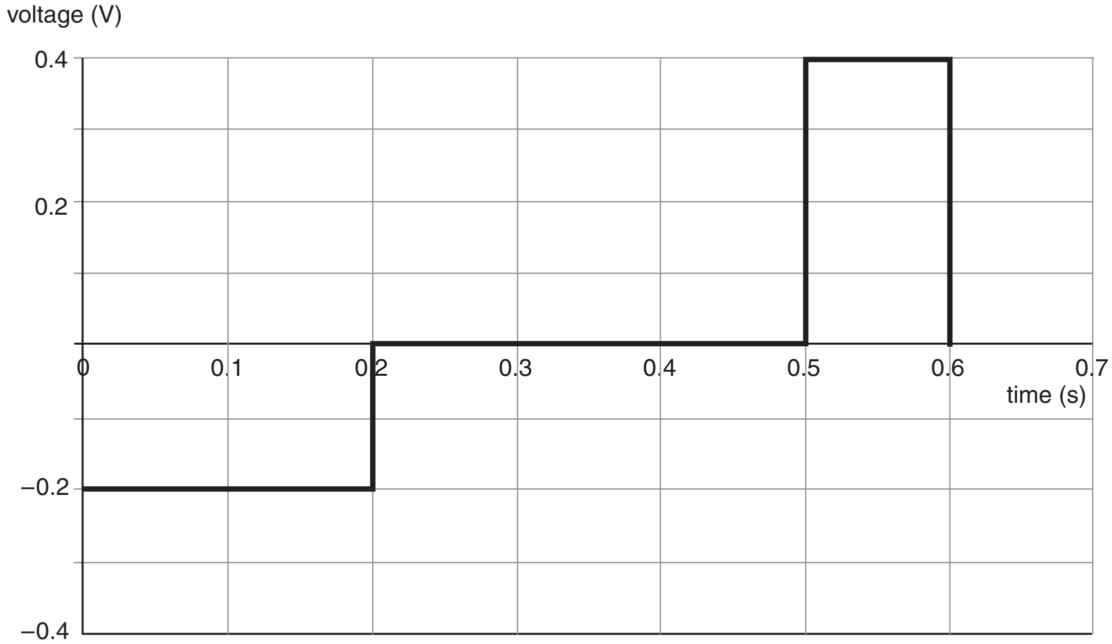
For the first 0.2 s, $\varepsilon = -\frac{N\Delta\Phi}{t} = \frac{-200 \times (2.0 \times 10^{-4})}{0.2} = -0.2 \text{ V}$ 1 mark

Note: consequential answer, $\varepsilon = \text{Question } 6 \times 1000$

For the next 0.3 s, $\varepsilon = 0$ as the flux is not changing. 1 mark

For the final 0.1 s, $\varepsilon = -\frac{N\Delta\Phi}{t} = \frac{-200 \times (-2.0 \times 10^{-4})}{0.1} = 0.4 \text{ V}$ 1 mark

Note: consequential answer, $\varepsilon = \text{Question } 6 \times 2000$



1 mark

1 mark for correct graph

Note that it is acceptable for the signs on the values to be reversed throughout, i.e. +0.2 V and –0.4 V.

Question 8

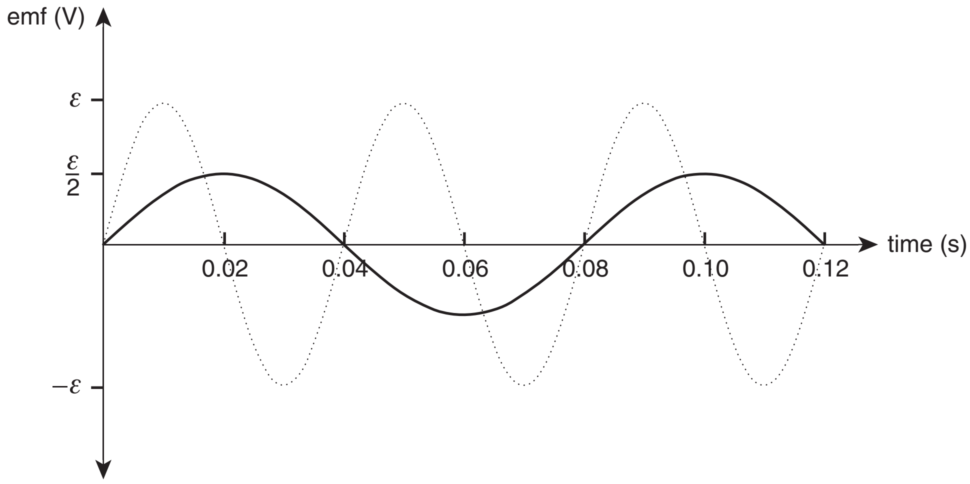
From the graph, $T = 0.04$ s. 1 mark

$f = \frac{1}{T} = \frac{1}{0.04} = 25 \text{ Hz}$ 1 mark

Question 9

The period will be double (0.08 s). 1 mark

Maximum emf will be halved $\left(\frac{\varepsilon}{2}\right)$. 1 mark



Question 10

Faraday's

flux

Lenz's

opposes

2 marks

2 marks for all answers correct

1 mark for 2 or 3 answers correct

Question 11

Using the right-hand grip rule, with fingers curled in the direction of current, the thumb will point to the RIGHT. This indicates the direction of field within the solenoid (position *X*) and indicates the location of the north pole for the external field around the solenoid.

Hence the correct answers are

Direction of field at point *X*: **A** 1 mark

Direction of field at point *Y*: **A** 1 mark

Direction of field at point *Z*: **B** 1 mark

Question 12

$V_{\text{peak - peak}} = 2 \times \sqrt{2} \times V_{\text{RMS}} = 2 \times \sqrt{2} \times 1200$ 1 mark

$V_{\text{peak - peak}} = 3394$ V 1 mark

Question 13

$\frac{V_\text{P}}{V_\text{s}} = \frac{N_\text{P}}{N_\text{S}} \qquad \frac{1200}{240} = \frac{N}{20}$ 1 mark

$N = 100$ turns 1 mark

Question 14

If the transformer is close to the house the electricity will be transmitted along
the supply lines at a high voltage, 1 mark
hence the current in the lines will be low. 1 mark

Since $P_{\text{loss}} = I^2R$, this will result in a lower power loss. 1 mark

Question 15

$V_{\text{drop}} = 240 - 180 = 60 \text{ V}$ 1 mark

$I_{\text{lines}} = \dfrac{V_{\text{drop}}}{R_{\text{lines}}} = \dfrac{60}{5} = 12 \text{ A}$ 1 mark

$P_{\text{loss}} = I^2R = (12^2) \times 5 = 720 \text{ W}$ 1 mark

Question 16

$P = VI = 12 \times 240$ 1 mark

$P = 2880 \text{ W}$ 1 mark

Note: consequential answer, P = current calculated in Question 15 $\times$ 240

Area of study 2 – Interactions of light and matter

Question 1

the sun 1 mark

excitation 1 mark

frequencies 1 mark

Question 2

Narella is correct. 1 mark

Bright fringes occur at points of constructive interference, i.e. antinodes. 1 mark

Waves must be in phase at this point. 1 mark

Two troughs will cause constructive interference as well as two crests and all variations in between. 1 mark

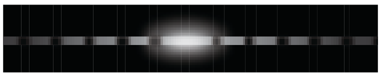
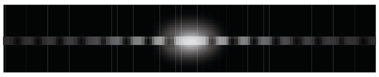
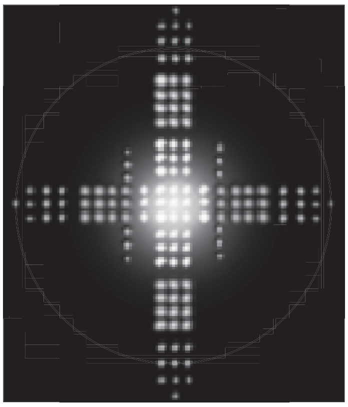
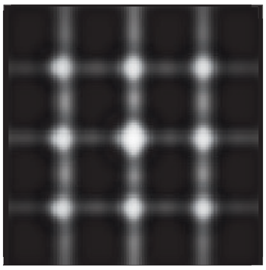
Question 3 **B** 1 mark

Fringe width separation is proportional to wavelength.

As the wavelength of blue light is shorter than that of red light, the fringes will be closer together.

Brightness is not affected by wavelength.

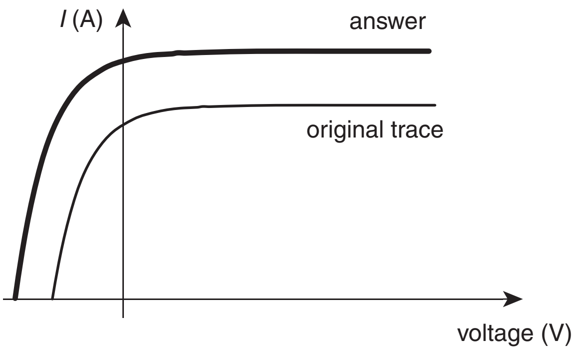
Question 4

Image	Medium
	Fine mesh placed in front of the laser
	Crossed slits of 0.02 mm placed in front of the laser
	A single slit of 0.02 mm placed in front of the laser
	A single slit of 0.16 mm placed in front of the laser

4 marks

1 mark for each correct arrow.

Question 5



2 marks

1 mark for greater stopping voltage

1 mark for greater current

Question 6

$\frac{1}{2}mv^2 = eV_0$

$p = (2meV_0)^{\frac{1}{2}}$ 1 mark

$p = (2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 2.22)^{\frac{1}{2}}$ 1 mark

$p = 8.04 \times 10^{-25}$ kg m s^{-1} 1 mark

Question 7 **C** 1 mark

Increasing intensity increases the number of photons delivered to the metal, therefore increasing the number of photoelectrons emitted, not their energy.

Question 8 **C** 1 mark

These are diffraction patterns.

Question 9

$\lambda = \frac{h}{p}$ but $p = (2 \times \mathrm{KE} \times m)^{\frac{1}{2}}$

$\lambda = \frac{h}{(2 \times \mathrm{KE} \times m)^{\frac{1}{2}}}$ 1 mark

$\lambda = \frac{6.63 \times 10^{-34}}{(2 \times (0.17 \times 1.6 \times 10^{-19}) \times (9.1 \times 10^{-31}))^{\frac{1}{2}}}$ 1 mark

$\lambda = 2.97 \times 10^{-9}$ m 1 mark

Question 10

Energy lost by electron $= 3.4 - 1.5 = 1.9$ eV $= 3.04 \times 10^{-19}$ J 1 mark

$E = hf$

$3.04 \times 10^{-19} = 6.63 \times 10^{-34} f$

$f = 4.57 \times 10^{14}$ s^{-1} 1 mark

Question 11 1 mark

$n = 4$

SECTION B – DETAILED STUDIES

Detailed study 1 – Synchrotron and its applications

Question 1

Column A: term	Column B: explanation
bright	A beam of specific wavelength can be selected
wide spectrum	Radiation is far more intense than conventional X-rays
tuneable	Beam has a narrow angular spread
collimated	Radiation is emitted in a range of frequencies.

3 marks

3 marks for 4 arrows correct
2 marks for 3 arrows correct
1 mark for 2 arrows correct

Question 2

1.0 eV is the amount of energy gained by an electron as it is accelerated through 1.0 V. 1 mark

Hence, to supply an electron with 4.0 keV of energy the voltage required is 4000 V. 1 mark

Question 3

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

$(1.6 \times 10^{-19}) \times 4000 = \frac{1}{2}(9.1 \times 10^{-31}) \times v^2$ 1 mark

$6.4 \times 10^{-16} = (4.55 \times 10^{-31})v^2$ 1 mark

$v = 3.8 \times 10^7 \text{ ms}^{-1}$ 1 mark

Note: consequential answer, $v = \sqrt{\text{Question } 2 \times (3.5 \times 10^{11})}$

Question 4 **F** 2 marks

This is found using the right-hand slap rule: placing fingers in the direction of magnetic field (towards the left), thumb in the direction of conventional current (down: note that this is opposite to the direction of electron flow), the palm indicates the direction of the force as into the page.

Question 5

$r = \frac{mv}{Bq} \quad 0.8 = \frac{(9.1 \times 10^{-31}) \times 0.1 \times (3.0 \times 10^8)}{B \times (1.6 \times 10^{-19})}$ 1 mark

$B = 2.1 \times 10^{-4} \text{ T}$ 1 mark

Question 6

$E = \frac{hc}{\lambda} \quad (6.0 \times 10^3) = \frac{(4.14 \times 10^{-15}) \times (3.0 \times 10^8)}{\lambda}$ 1 mark

$\lambda = 2.1 \times 10^{-10}$ m 1 mark

Question 7

$E_{k_{\text{electron}}} = \frac{1}{2}mv^2 = \frac{1}{2} \times 9 \times 10^{-31} \times (3.0 \times 10^7)^2$

$= 4.1 \times 10^{-16}$ J 1 mark

Energy of incident photon $= 6.0 \times 10^3 \times 1.6 \times 10^{-19}$

$= 9.6 \times 10^{-16}$ J 1 mark

Energy of scattered photon $= 9.6 \times 10^{-16} - 4.1 \times 10^{-16}$

$= 5.5 \times 10^{-16}$ J 1 mark

$\lambda = \frac{hc}{E} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{5.5 \times 10^{-16}} = 3.6 \times 10^{-10}$ m 1 mark

Question 8

When Thomson scattering occurs the collision is elastic, the photon loses no energy and hence there is no change in wavelength.

$\lambda_{\text{scattered photon}} = 2.1 \times 10^{-10}$ m 2 marks

Note: consequential answer, $\lambda_{\text{scattered photon}}$ = Question 6

Question 9

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

$1 \times \lambda = 2 \times (2.2 \times 10^{-10})\sin(17°)$ 1 mark

$\lambda = 1.3 \times 10^{-10}$ m 1 mark

Question 10

The second peak will occur when $n = 2$.

$2 \times (1.3 \times 10^{-10}) = 2 \times (2.2 \times 10^{-10}) \times \sin(\theta)$ 1 mark

$\theta = 35.8°$ 1 mark

Hence the student is incorrect. 1 mark

Note: consequential answer, $\theta = \sin^{-1}\left[\frac{\text{Question 9}}{2.2 \times 10^{-10}}\right]$

Detailed study 2 – Photonics

Question 1

conduction band 1 mark

valence band 1 mark

frequency 1 mark

Question 2

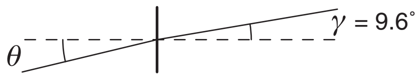
$\sin(I_C) = \dfrac{n_{\text{cladding}}}{n_{\text{core}}}$ 1 mark

$\sin(80.4°) \times 1.42 = n_{\text{cladding}}$ 1 mark

$n_{\text{cladding}} = 1.4$

Question 3

At the boundary between air and the fibre:



$\gamma = 90 - 80.4 = 9.6$

$\dfrac{\sin(\theta)}{\sin 9.6} = \dfrac{1.42}{1}$ 1 mark

$\theta = 13.5°$ 1 mark

Question 4

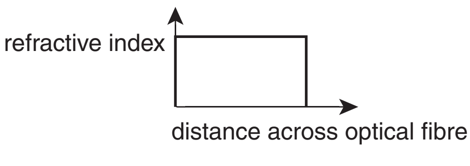
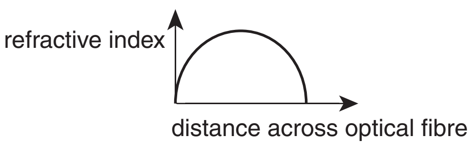
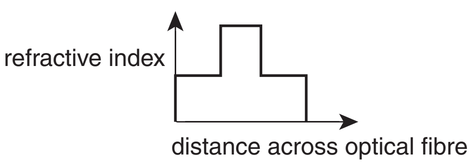
The movement of the building makes the curvature in the fibre either more or less.

This will change the incident angle of light meeting the boundary of the fibre. 1 mark

A greater degree of bending will allow more light to escape, less bending less light will escape. 1 mark

Hence by measuring the intensity of the light any changes in the light at the sensor will monitor the movement of the building. 1 mark

Question 5

Graph of refractive index across fibre	Characteristic of fibre
	Higher-order rays take the same time to reach the end of the fibre as lower-order rays
	Multimode rays are possible but losses will occur.
	It is only possible for a single mode of ray to be transmitted down this fibre.

3 marks

1 mark for each correct arrow

Question 6 **C** 1 mark

The laser uses an external source of photons that interact with the medium inside the laser. The atoms inside the laser absorb a photon and hence are stimulated to emit a photon of the same wavelength as the original photon. This is stimulated emission.

Question 7

Rayleigh scattering and absorption. 1 mark

Question 8

If the wavelength is smaller than the size of the particles, Rayleigh scattering occurs. 1 mark

If the wavelength is larger than the size of the particles, it interacts with the electrons in atoms and molecular bonds. 1 mark

Question 9 **C** 1 mark

Impurities will absorb the light in the fibre, emitting it as heat (IR radiation) and other wavelengths of light in random directions.

Question 10 **D** 1 mark

The Rayleigh scattering is proportional to $\frac{1}{\lambda^4}$, therefore $\left(\frac{1}{2}\right)^4 = \frac{1}{16}$.

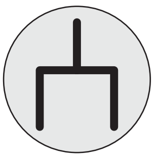
Question 11

Probable cause is modal dispersion. 1 mark

This is caused by rays taking paths of different lengths in the fibre and arriving at different times. 1 mark

Using a multimodal fibre with varying refractive index could rectify this. 1 mark

Question 12



Since this is a coherent bundle the image is unchanged but because the fibre has been bent up the image is inverted. 1 mark

Question 13

A and **C**. 2 marks

1 mark for each correct answer

Short-distance communication systems are not as susceptible to attenuation and modal losses. Therefore a lower-power source (LED) and an optical fibre that is more susceptible to modal losses (multimode fibre) would be acceptable.

Detailed study 3 – Sound

Question 1

energy 1 mark
compressions and rarefactions 1 mark
plane 1 mark

Question 2

$V = f\lambda$

$\lambda = 0.6$ m from diagram

$0.8 = 0.6f$ 1 mark

$f = 0.133$

In one minute there will be $60 \times 0.133 = 8$ periods. 1 mark

Question 3

Trudy should listen to Jo and double the sound intensity level. 1 mark

We would hear a doubling of amplitude if the sound intensity was doubled. 1 mark

Doubling the sound intensity would increase the dB level by $10\log(2) = 3.01$ dB. 1 mark

The students would only just be able to notice this increase. 1 mark

Question 4

$$\frac{I_1}{I_2} = \frac{r_2^2}{r_1^1}$$

$$r_2^2 = \frac{2 \times 4^2}{0.8}$$ 1 mark

$r_2 = 6.3$ m 1 mark

therefore, she has walked $6.3 - 4 = 2.3$ m from her original position. 1 mark

Question 5 C 1 mark

The curves are plotted by measuring the intensity at which a note must be played to be heard at a particular perceived intensity (e.g. a 100 Hz note must have an intensity of 60 dB to be perceived as 40 phon by the listener).

Question 6

change in dB level = 80 – 50 = 30 dB 1 mark

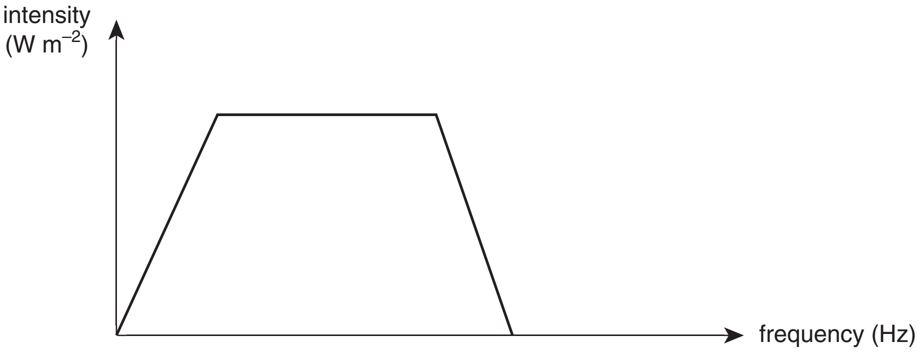
$$30 = 10\log\left(\frac{I_2}{I_1}\right)$$ 1 mark

$$\frac{I_2}{I_1} = 1000$$ 1 mark

Question 7 **D** 1 mark

Baffles reduce the resonance of the enclosure, thus giving a flatter frequency response.

Question 8



1 mark

1 mark for a graph showing the flatter region in the low frequencies

Question 9 **C** 1 mark

Since a maximum intensity is measured at this point, it must be an antinodal point. The sound here will oscillate between the highest maximum positive and maximum negative amplitudes.

Question 10

$\frac{0.765}{0.085} = 9$

Therefore there must be $2\frac{1}{4}$ wavelengths present in the tube at this time. 1 mark

This is the 5th harmonic. 1 mark

Question 11

$V = f\lambda$

$f = \frac{340}{0.085 \times 4}$

$f = 1000$ Hz 1 mark

Question 12

10 000 1 mark
coil 1 mark
under high tension 1 mark

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