Neap:

Trial Examination 2008

VCE Physics Unit 4

Written Examination

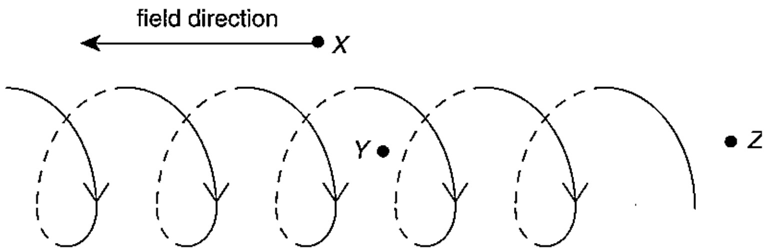
Suggested Solutions

SECTION A – CORE

Area of study 1 – Electric power

Question 1

Arrows should point downwards on the solid part of the coil.



Use RH grip rule: North pole is at Z so point thumb to right, fingers curl around out of the page.

2 marks

Question 2 **A** 2 marks

The field inside the solenoid will be in the opposite direction to the field outside (so it will be to the right). The field strength inside the solenoid is stronger than outside as the field lines are closer together.

Question 3

Any two of the following:

- increase the number of turns in the coil
- increase the current in the coil
- insert an iron core into the coil

2 marks

Question 4

$I = \frac{V}{R} = \frac{6}{60} = 0.1 \text{ A}$ 1 mark

$F = NBIl = 20 \times 0.1 \times 0.1 \times 0.03$ 1 mark

$F = 0.006 \text{ N}$ 1 mark

Question 5

The direction of the force is **out of the page.** 1 mark
This is predicted using the **right-hand push rule.** 1 mark
The current is to the right (thumb), field is up (fingers), so the force is out of the page (palm). 1 mark

Question 6

The coil will rotate through 90°, oscillate and then stop. 1 mark
The force on side AB remains in the same direction (out of the page). 1 mark
This means that when the coil moves past the horizontal position, the force causes torque in the opposite direction and it rotates back, oscillates about the horizontal as the torque alternates, and eventually stops. 1 mark

Question 7

0 Wb 2 marks

Since the coil is parallel with the field, there is no area through which the field lines pass, so flux is zero.

Question 8

$$\text{emf}_{\text{ave}} = \frac{N\Delta(BA)}{t}$$

$A = (0.03 \times 0.02) = 6 \times 10^{-4}\ \text{m}^2$ 1 mark

$2.0 \times 10^{-3} = \dfrac{(20 \times 0.1 \times 6 \times 10^{-4})}{t}$ 1 mark

$t = 0.6$ seconds 1 mark

Question 9

Molly is correct. 1 mark

Flux through the loop is increasing as the loop rotates. 1 mark

Lenz's law predicts that the induced current will have a field that **opposes** the change in flux, so the induced field will be down, and using the right hand grip rule the current direction can hence be predicted as clockwise (i.e. *ABCD*). 1 mark

Question 10

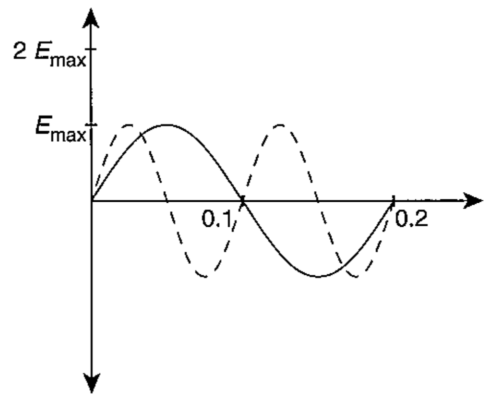
$f = \dfrac{1}{T} = \dfrac{1}{0.1}$ 1 mark

$f = 10$ Hz 1 mark

Question 11

$$\text{emf}_{\text{ave}} = \frac{N\Delta(BA)}{t}$$

If the frequency is halved, the period is doubled. This means emf will be halved, and that the period of the new signal will be doubled.
If the field strength is doubled, the emf is doubled.
The overall effect is that there will be no change to the maximum emf, but the period will be double.



1 mark for correct period

1 mark for correct maximum EMF

Question 12

$V_{p-p} = 2\sqrt{2}V_{RMS} = 2\sqrt{2} \times (3.6 \times 10^3)$ — 1 mark

$V_{p-p} = 10182 \text{ V} = 1.0 \times 10^4 \text{ V}$ — 1 mark

Question 13

When the voltage is stepped up the current decreases, since $P_{trans} = V_{trans}I_{trans}$ — 1 mark

By reducing the current, the power loss is decreased, since $P_{loss} = I^2R$ — 1 mark

The voltage must be stepped down again after transmission to correctly operate the appliances. — 1 mark

Question 14

$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

$$\frac{3600}{240} = \frac{N_2}{100}$$ 1 mark

$N_2 = 1500$ turns — 1 mark

Question 15

$I_{trans} = \frac{P_{trans}}{V_{trans}} = \frac{20\ 000}{3600} = 5.55 \text{ A}$ — 1 mark

$V_{drop} = I_{trans}R_{line} = 5.55 \times 50 = 278 \text{ V}$ — 1 mark

$V_{supply} = 3600 - 278 = 3322 \text{ V}$ — 1 mark

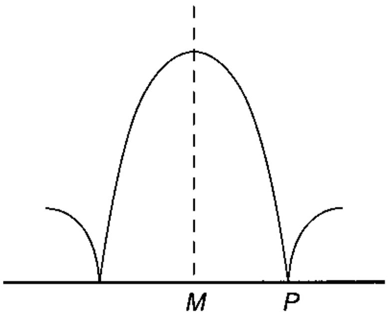
Question 16

No power would reach the mine. — 1 mark

The transformer requires an alternating current to operate but the batteries only supply DC. — 1 mark

Area of study 2 – Light and matter

Question 1



1 mark for maximum at *M*
1 mark for node at *P*

Question 2

Path difference for point *P* which is the first minima is $\frac{\lambda}{2}$. 1 mark

$\frac{\lambda}{2} = \frac{532}{2} = 266$ nm 1 mark

Question 3

The wavelength of red light is greater than the wavelength of green light. 1 mark
Therefore the pattern will spread out. 1 mark

Question 4

Young's double slit interference experiment demonstrates that light has a wave-like nature (as constructive and destructive interference are characteristics of waves). 2 marks

Question 5

Using the concept of a particle model for light, the red light photon does not have enough energy to cause the photoemission of electrons, whereas the blue light photon does. 2 marks

Question 6

Doubling the intensity of the blue light doubles the current because there are twice as many photons coming in, causing twice as many photoelectrons to be emitted. 2 marks

Question 7

The threshold frequency for this metal is given by $E = hf$.

$f = \frac{E}{h} = \frac{2.2}{4.14 \times 10^{-15}} = 5.3 \times 10^{14}$ Hz 2 marks

Question 8

$c = \lambda f$

$\lambda = \frac{c}{f} = \frac{3.0 \times 10^{8}}{5.2 \times 10^{14}} = 5.8 \times 10^{-7}$ m 1 mark

Question 9

The photon momentum of a single photon of orange light is given by $p = \frac{h}{\lambda}$.

$$p = \frac{6.16 \times 10^{-34}}{5.8 \times 10^{-7}} = 1.06 \times 10^{-27} \text{ N s}$$

Note: Award a consequential mark for $p = \frac{6.16 \times 10^{-34}}{\text{answer Q8}}$. 2 marks

Question 10

$E_3 - E_2 = \frac{hc}{\lambda} = 12.0 \text{ eV} - 10.1 \text{ eV} = 1.9 \text{ eV}$ 1 mark

$$\lambda = \frac{(4.14 \times 10^{-15}) \times (3.0 \times 10^{8})}{1.9}$$

$= 6.54 \times 10^{-7}$ m 1 mark

Question 11

$p = mv$

$= (9.1 \times 10^{-31}) \times (3.2 \times 10^{7})$ 1 mark

$= 2.9 \times 10^{-23}$ N s 1 mark

Question 12

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

$= \frac{6.63 \times 10^{-34}}{2.91 \times 10^{-23}}$ 1 mark

$= 2.28 \times 10^{-8}$ m 1 mark

Note: Award a consequential mark for $\lambda = \frac{6.63 \times 10^{-34}}{\text{answer Q11}}$.

Question 13

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

$= \frac{6.63 \times 10^{-34}}{1500 \times \frac{100}{3.6}}$ 1 mark

$= 1.59 \times 10^{-35}$ m

This is extremely small and is therefore unobservable. 1 mark

Detailed study 1 - Synchrotron (26 marks)

Question 1 **D** 2 marks

Potential difference of 10 kV gives one electron 10 keV of kinetic energy.

Question 2 **B** 2 marks

Use the left-hand *FBI* rule or the right-hand slap rule.

Question 3 **C** 2 marks

The kinetic energy of the electron increases by a factor of 4, so the speed increases by a factor of 2, and the force increases by a factor of 2.

Question 4 **D** 2 marks

Beamline and storage ring.

Question 5 **C** 2 marks

Booster ring and linac.

Question 6 **A** 2 marks

The function of the booster ring in the synchrotron is to accelerate the electrons up to orbit speed.

Question 7 **B** 2 marks

The function of the storage ring in the synchrotron is to maintain the electrons at a certain speed in their circular orbits.

Question 8 **D** 2 marks

The brightness of synchrotron radiation is best described as the concentration of the emitted light.

Question 9 **B** 2 marks

The divergence of synchrotron radiation is best described as the spread of the beam.

Question 10 **C** 2 marks

The energy of the incident photon is given by $E = \frac{hc}{\lambda}$.

Question 11 **D** 2 marks

The amount of energy lost in this collision is given by the difference of the incident X-ray and the scattered X-ray using $E = \frac{hc}{\lambda}$.

Question 12 **A** 2 marks

The extra energy has gone into the kinetic energy of an electron.

Question 13 **C** 2 marks

Compton scattering provides evidence supporting the particle nature of light.

Detailed study 2 – Photonics (26 marks)

Question 1 **B** 2 marks

Energy in joules = Energy in eV × 1.6 × 10^{-19} = 1.33 × (1.6 × 10^{-19}) = 2.1 × 10^{-19} J

Question 2 **C** 2 marks

$$\lambda = \frac{hc}{E_{\text{gap}}} = \frac{(4.14 \times 10^{-15}) \times (3 \times 10^{8})}{1.33} = 9.3 \times 10^{-7}\ \text{m}$$

Question 3 **C** 2 marks

Orange light has a shorter wavelength than infrared light.

Since $E_{\text{gap}} = \frac{hc}{\lambda}$, a shorter wavelength will result in a higher energy gap energy.

Question 4 **A** 2 marks

The band gap for insulators is very large, making it impossible for electrons to move from the valence band into the conduction band, so they cannot conduct.

Question 5 **A and C** 2 marks

Laser light is monochromatic and coherent. Different lasers can produce light of different wavelengths, so **B** is incorrect. Fluorescence is a different method of light production, so **D** is incorrect.

Question 6 **D** 2 marks

The stimulated emission refers to the process whereby a photon released by one atom stimulates other atoms to release identical photons in phase.

Question 7 **D** 2 marks

For total internal reflection, $n_1 \sin i_c = n_2 \sin 90°$.

$$1.47 \sin i_c = 1.39 \sin 90°$$
$$i_c = 71°$$

Question 8 **B** 2 marks

$i_c = \sin^{-1}\left(\frac{n_{\text{cladding}}}{n_{\text{core}}}\right)$ so in order to increase i_c, the value of $\frac{n_{\text{cladding}}}{n_{\text{core}}}$ must be as close to 1 as possible.

To achieve this, n_{cladding} should be increased so that it is closer to (but not equal to) n_{core}.

Question 9 **C** 2 marks

$$n_1 \sin\alpha = n_2 \sin(90 - i_c)$$

$$1 \times \sin(47°) = 1.47 \sin(90° - i_c)$$

$$\sin(90° - i_c) = \frac{\sin(47°)}{1.47}$$

$$(90° - i_c) = 29.8°$$

$$i_c = 60.8°$$

Question 10 **A** 2 marks

Attenuation is defined as the amount of optical power loss within the optic fibre.

Question 11 **C** 2 marks

Raleigh scattering is proportional to λ^{-4} so as λ increases, the amount of Raleigh scattering decreases very rapidly. This is best represented by **C**.

Question 12 **D** 2 marks

Multimode graded-index fibre has less modal dispersion than multimode step-index fibre as lower modes are slowed down, enabling higher modes to 'keep up with them' so that all the modes travel at the same speed. This means that these fibres are far better for long distance communication than multimode step index fibres.

Question 13 **D** 2 marks

When the bridge bends, the optic fibres also bend more. This means that the angle that the light is incident on the boundary between the cladding and the core may be less than the critical angle, and so total internal reflection may not occur. The result is that less intensity is detected at the detonator.

Detailed study 3 - Sound (26 marks)

Question 1 **C** 2 marks

The dust particle oscillates back and forth in a horizontal direction.

Question 2 **B** 2 marks

This demonstrates the longitudinal nature of sound waves.

Question 3 **A** 2 marks

Point P will be a pressure node (as the pipe is open to the atmosphere there).

Question 4 **B** 2 marks

Point Q will be a pressure antinode.

Question 5 **A** 2 marks

The first harmonic represents half a wavelength in the pipe. Using $c = \lambda f$ gives $\lambda = 0.5$ m.

Question 6 **D** 2 marks

The frequency of the second harmonic for this xylophone is twice the frequency of the first harmonic.

Question 7 **D** 2 marks

Resonance is an example of standing waves.

Question 8 **C** 2 marks

Dynamic microphones work because the air pressure variations guarantee an induced current as the coil moves relative to the magnet.

Question 9 **B** 2 marks

The wavelength of the double bass note is given by $\lambda = \frac{c}{f} = \frac{330}{165} = 2.0$ m.

Question 10 **A** 2 marks

The wavelength of the flute note is given by $\lambda = \frac{c}{f} = \frac{330}{3300} = 0.1$ m.

Question 11 **A** 2 marks

Jasmeet hears both the double bass note and the flute note because he is in a direct line with both frequencies.

Question 12 **B** 2 marks

Jasmine hears only the bass guitar note, not the flute note because the high frequencies do not diffract through the doorway.

Question 13 **B** 2 marks

The diffraction of the different frequencies at the doorway explains what Jasmeet and Jasmine each hear.