2019 VCE Physics (NHT) examination report

General comments

- Students should be aware of the Section B instructions, specifically, ‘In questions where more than one mark is available, appropriate working **must** be shown.’ Responses that do not include a formula and a full substitution may not be awarded full marks.
- Students should take care to ensure they are responding in the correct units. If a unit is provided in an answer box, students must respond in that unit.
- Answers should be given in decimal form and not in fractions or surds.
- When plotting graphs, students should take care when marking out and labelling their axes.

Specific information

This report provides sample answers or an indication of what answers may have included. Unless otherwise stated, these are not intended to be exemplary or complete responses.

Section A

Question	Answer	Comments
1	B	The field from N to S should be identified by an arrow pointing to the right.
2	D	The right hand slap rule should have been used, with fingers towards N, thumb towards W and palm facing downwards.
3	C	$F = BIl$ $F = 5 \times 10^{-5} \times 1000 \times 1$ $F = 5 \times 10^{-2}\ N$
4	D	$\Delta GPE = mg\Delta h$ $\Delta GPE = 10 \times 3.7 \times 2$ $\Delta GPE = 74\ J$
5	A	$\frac{N_p}{N_s} = \frac{V_p}{V_s}$ $\frac{V_p}{V_s} = \frac{240}{12} = \frac{20}{1}$
6	A	12 V_{DC} is equivalent to 12 V_{RMS}.

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Question	Answer	Comments
7	C	The display should show double the period and half the amplitude of the original display.
8	C	$\frac{mv^2}{r} = mg$ $v = \sqrt{rg} = \sqrt{1.6 \times 9.8}$ $v = 3.96\ m\ s^{-1}$
9	A	Centripetal force acts towards the centre of rotation.
10	D	The frequency remains the same, while the wavelength changes in response to the change in velocity.
11	A	Polarisation is particular to transverse rather than longitudinal waves. The other options were not determined by the type of wave or were incorrect.
12	C	Electromagnetic radiation can be produced by accelerating charges such as in a synchrotron.
13	B	When mechanical waves travel through a medium, only energy is transferred. There is no net movement of the medium.
14	D	
15	B	$w \propto \frac{1}{a}$ As the slit widens, the width of the peak will narrow.
16	A	$\gamma = \frac{1}{\sqrt{1 - 0.2^2}}$ $\gamma = 1.02$
17	D	$t = t_0\gamma$ $\gamma = \frac{16}{2.2} = 7.3$
18	C	$E = (\gamma - 1)mc^2$ $\Rightarrow (\gamma - 1) = 10$ $\therefore \gamma = 11$
19	B	Absorption means that the arrow should point up to indicate the electron gaining energy.
20	B	‘Precise’ implies that results are grouped close together. ‘Inaccurate’ implies that they are grouped away from the true value.

Section B

Question 1a.

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

$$V \times 1.6 \times 10^{-19} = 0.5 \times 9.1 \times 10^{-31} \times (4.2 \times 10^7)^2$$

$$V = \frac{0.5 \times 9.1 \times 10^{-31} \times (4.2 \times 10^7)^2}{1.6 \times 10^{-19}}$$

$$V = 5016\, V$$

Students must ensure that they show all working.

Question 1b.

$$F = Bqv$$
$$F = (5.0 \times 10^{-2}) \times 1.6 \times 10^{-19} \times 4.2 \times 10^7$$
$$F = 3.4 \times 10^{-13}\ \mathrm{N}$$

Question 1c.

Students were required to state that the path would be part of a circle (or circular). The reason is because the force is always at right angles to the path of the electrons.

Question 2a.

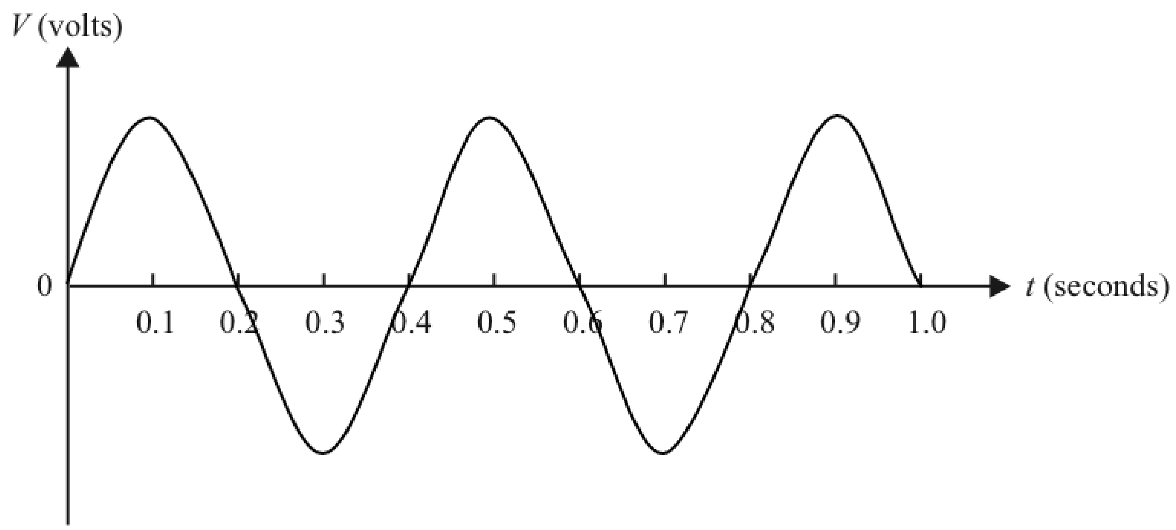
$$\varepsilon = -N\frac{\Delta \emptyset}{\Delta t}$$

$$\varepsilon = 20 \times 4.0 \times 10^{-2} \times \frac{0.010}{0.10}$$

$$\varepsilon = 0.080\ \mathrm{V}$$

The question asked for the magnitude of the EMF, so the minus sign has been omitted from the working.

Question 2b.



Students were required to draw a sine wave of 2.5 cycles. An inverted graph was also acceptable.

Question 3a.

$F = nIlB$
$F = 10 \times 2.0 \times 0.1 \times 2.0 \times 10^{-3}$
$F = 4.0 \times 10^{-3}$ N

Question 3b.

Students were required to indicate that the split ring commutator reverses the current in the loop every half turn to keep the motor turning in the same direction.

Question 4a.

$$I_{line} = \frac{P_{globe}}{V_{globe}}$$

$$I_{line} = \frac{480}{240} = 2 \text{ A}$$

$P_{loss} = I^2R$

$P_{loss} = 2^2 \times 40$

$P_{loss} = 160\ W$

Question 4b.

$V_{line} = IR$

$V_{line} = 2.0 \times 40 = 80\ V$

$V_{in} = 240 + 80 = 320\ V_{RMS}$

Question 4c.

$$I_{wires} = \frac{1}{8} \times 2.0 = 0.25 \text{ A}$$

$P_{loss} = I^2R = 0.25^2 \times 40$

$P_{loss} = 2.5\ W$

Question 5a.

$mg = kx$

$$x = \frac{2.0 \times 10}{100}$$

$x = 0.20\ m$

Question 5bi.

By conservation of energy:

$$mg\Delta x = \frac{1}{2}k\Delta x^2$$

$$\Delta x = \frac{2mg}{k} = \frac{2 \times 2.0 \times 10}{100}$$

$\Delta x = 0.40\ m$

Question 5bii.

Total energy of the system:

$E_{total} = mgh = 2.0 \times 10 \times 0.4$

$E_{total} = 8\,J$

The maximum velocity occurs at the mid-point where $\Delta x = 0.20$ m.

$GPE_{mid} = mg\Delta x = 2.0 \times 10 \times 0.20$

$GPE_{mid} = 4.0\,J$

$SPE_{mid} = \frac{1}{2}k\Delta x^2 = 0.5 \times 100 \times 0.20^2$

$SPE_{mid} = 2.0\,J$

Therefore, there is 2.0 J of energy as kinetic energy.

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

$2 = 0.5 \times 2.0 \times v^2$

$\therefore v = 1.4\,m\,s^{-1}$

Question 6a.

$u_v = 40sin30 = 20\,m\,s^{-1}$

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

$0 = 20^2 + (2 \times -9.8 \times x)$

$x = \frac{400}{19.6} = 20.4\,m$

Question 6b.

$u_h = 40cos30 = 34.6\,m\,s^{-1}$

$t = \frac{104}{34.6} = 3.0\,sec$

$x = ut + \frac{1}{2}at^2$

$x = (20 \times 3) + (0.5 \times -9.8 \times 3^2)$

$x = 15.9\,m$

Question 7a.

Impulse = change in momentum

$\Delta p = p_f - p_i$

$\Delta p = 8 - (-12)$

$\Delta p = 20\,kg\,m\,s^{-1}\ or\ 20\,N\,s$

Question 7b.

$I = Ft$

$20 = F \times 0.01$

$\therefore F = 2000\ N$

Question 7c.

$Ek_{initial} = \frac{1}{2}mv^2$

$Ek_{initial} = (0.5 \times 2.0 \times 10^2) + (0.5 \times 0.2 \times 60^2)$

$Ek_{initial} = 460\ J$

$Ek_{final} = \frac{1}{2}mv^2$

$Ek_{final} = (0.5 \times 0.2 \times 40^2)$

$Ek_{final} = 160\ J$

The reduction in kinetic energy indicates that the collision is inelastic.

Question 8a.

Students were required to state that uncertainty is the margin for error in a measurement and its effects can be reduced by repeated measurements.

Question 8b.

Independent variable: period or speed of the car

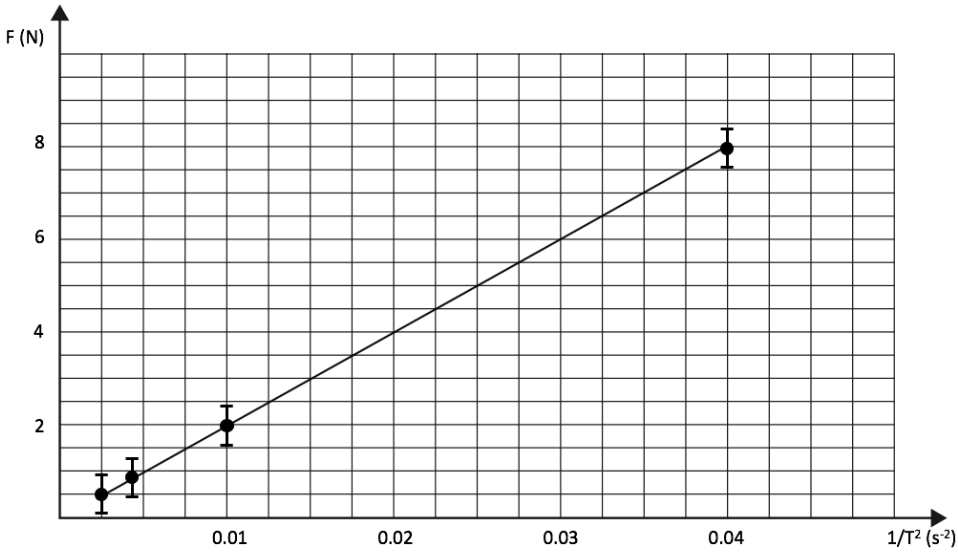
Dependent variable: force

Controlled variables: the mass of the car and the length of the string (or radius)

Question 8ci.

Period T (s)	$1/T^2$ (s^{-2})	Force F_T (N)
5.00	0.04	8
10.0	0.01	2
15.0	4.4×10^{-3}	0.9
20.0	2.5×10^{-3}	0.5

Question 8cii.



Question 8d.

Gradient $= \frac{rise}{run} = \frac{8-0.5}{0.04-0.0025} = 200$

$200 = 4\pi^2 mr$

$m = \frac{200}{4\pi^2} = 5.1\ kg$

Question 9

98 N and upwards

Question 10a.

Radius = $3.4 \times 10^6 + 1.6 \times 10^6 = 5.0 \times 10^6$ m

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

$$T = \sqrt{\frac{4\pi^2 \times (5.0 \times 10^6)^3}{6.7 \times 10^{-11} \times 6.4 \times 10^{23}}}$$

$$T = 1.1 \times 10^4\ s$$

Question 10b.

Students were required to state that if the radius increased the velocity would decrease. The most appropriate way to justify this was to refer to the formula $v = \sqrt{\frac{GM}{r}}$.

Question 11a.

Students were required to state that for the X-rays to have the same diffraction pattern as the electrons they must have the same wavelength. For the X-rays and electrons to have the same wavelength they must have the same momentum. In this case the energies will be different.

Question 11b.

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

$$5000 \times 1.6 \times 10^{-19} = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{5000 \times 1.6 \times 10^{-19}}{0.5 \times 9.1 \times 10^{-31}}}$$

$$v = 4.2 \times 10^7\ m\,s^{-1}$$

$$\lambda_{elec} = \frac{h}{mv}$$

$$\lambda_{elec} = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 4.2 \times 10^7}$$

$$\lambda_{elec} = 1.74 \times 10^{-11}\ m$$

The X-ray must have the same wavelength as the electron to produce the same diffraction pattern.

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

$$E = \frac{4.14 \times 10^{-15} \times 3 \times 10^8}{1.74 \times 10^{-11}}$$

$$E = 7.1 \times 10^4\ eV$$

Question 12a.

The core

Question 12b.

$$sin\theta_c = \frac{n_2}{n_1}$$

$$sin66 = \frac{1.42}{n_1}$$

$$n_1 = 1.55$$

Question 13a.

Students were required to state that at point C there would be ‘large waves’ due to constructive interference because the path difference is zero. It was not enough to simply state ‘due to constructive interference’ as this explains all maxima and the question referred specifically to the cause of the central maximum at point C.

Question 13b.

$$\Delta x = \frac{L\lambda}{d}$$

$$42 = \frac{420 \times \lambda}{60}$$

$$\therefore \lambda = 6\ m$$

Question 14a.

Question 14b.

$$\lambda = 2L$$

$$\lambda = 2 \times 0.92$$

$$\lambda = 1.84\ m$$

Question 14c.

$$v = f\lambda$$

$$224 = f \times 1.84$$

$$\therefore f = 122\ Hz$$

Question 15a.

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

$$E = \frac{4.14 \times 10^{-15} \times 3 \times 10^{8}}{1242 \times 10^{-9}}$$

$$E = 1.0\ eV$$

12.1 eV + 1.0 eV = 13.1 eV, which corresponds to the *n* = 5 state.

Question 15b.

Students were required to state that electrons can behave as waves with wavelengths equal to the deBroglie wavelength. The quantised energy levels exist where the orbital circumference permits the formation of a standing wave. Different energy levels are formed when the orbital circumference is a whole multiple of the deBroglie wavelength.

Question 16a.

$E = hf$

$E = 4.14 \times 10^{-15} \times 7.13 \times 10^{14}$

$E = 2.95\ eV$

The work function is 1.95 eV.

Therefore the stopping voltage will be 2.95 – 1.95 = 1.0 V.

Question 16b.

$c = f\lambda$

$3 \times 10^{8} = 1.04 \times 10^{15} \times \lambda$

$\therefore \lambda = 2.88 \times 10^{-7}$

$\lambda = 288\ nm$

Question 16c.

Students were required to identify that the particle model predicts a cutoff frequency below which no photoelectrons will be emitted regardless of intensity. The wave model predicts that photoelectron energy can be accumulated over time, while the particle model predicts that the energy of a photon is dependent on its frequency and is delivered in a single instant.

Question 17

$$t_{earth} = \frac{10.5}{0.85} = 12.35\ years$$

This is the dilated time as observed from the spaceship's frame of reference.

$t = t_0\gamma$

$t_{earth} = t_{spaceship} \times \gamma$

$12.35 = t_{spaceship} \times 1.90$

$t_{spaceship} = 6.5\ years$

Question 18

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

$$L = \frac{3.2 \times 10^{3}}{7.09}$$

$L = 4.5 \times 10^{2}\ m$

length of side along *x*-axis	4.5×10^{2} m
length of side along *y*-axis	3.2×10^{3} m
length of side along *z*-axis	3.2×10^{3} m

Students were required to identify that length contraction only occurs in the direction of travel and, therefore, the y and z dimensions would remain unchanged.

Question 19

Mass change = $(2 \times 3.3436 \times 10^{-27}) - 6.6465 \times 10^{-27}$
Mass change = 4.07×10^{-29} kg

$E = mc^2$

$E = 4.07 \times 10^{-29} \times 9 \times 10^{16}$

$E = 3.7 \times 10^{-12}\ J$