Neap

Trial Examination 2020

VCE Physics Unit 3

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

1	D
2	B
3	D
4	D
5	B
6	C
7	C
8	C
9	D
10	A

Question 1 D

The field lines travel from North to South, and so the direction of the field is to the left.

Question 2 B

If the speed is decreased, the radius of the path will decrease, as shown by $r = \frac{mv}{q_e B}$. If the velocity has decreased, then the force acting on the proton will decrease, as shown by $F_c = qvB$.

Question 3 D

$$F_{\text{new}} = \frac{k2Q2Q}{\left(\frac{r}{2}\right)^2}$$

$$= 4 \times (2)^2 \times F_{\text{original}}$$

$$= 16 \times F_{\text{original}}$$

Question 4 D

$$\frac{r^3_{\text{Rhea}}}{t^2_{\text{Rhea}}} = \frac{r^3_{\text{Helene}}}{t^2_{\text{Helene}}}$$

$$\frac{(527.1)^3}{(4.5)^2} = \frac{(377.4)^3}{t^2}$$

$$t = \sqrt{\frac{(527.1)^3 \times (4.5)^2}{(527.1)^3}}$$

$$= 7.4 \text{ days}$$

Question 5 B

Because of the orientation, the primary side is on the right and the secondary side is on the left.

$$\frac{N_{\text{primary}}}{N_{\text{secondary}}} = \frac{V_{\text{primary}}}{V_{\text{secondary}}}$$

$$\frac{6}{12} = \frac{12}{V_{\text{secondary}}}$$

$$V_{\text{secondary}} = 24.0 \text{ V}$$

Question 6 C

Graph **C** best represents the induced EMF, as EMF is proportional to the rate of change of flux.

Question 7 C

The vertical component of speed is 0.0 m s^{-1} and the horizontal component is 70.0cos30 = 60.6 m s^{-1}.
Speed at P is therefore 70.0cos30 = 60.6 m s^{-1}.

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Question 8 C

$$F_{\text{net}} = ma$$

$$10 = (3.0 + 2.0)a$$

$$a = 2.0 \text{ m s}^{-2}$$

$$T = 2.0 \times 3.0$$

$$= 6.0 \text{ N}$$

Question 9 D

$u = 0.0$, $s = 16.0$ and $t = 16.0$.

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

$$16.0 = 0.0 + \frac{1}{2}a(16.0)^2$$

$$a = 0.125 \text{ m s}^{-2}$$

$$1.0 \times 0.125 = 1.0 \times 9.8 \sin 15 - F$$

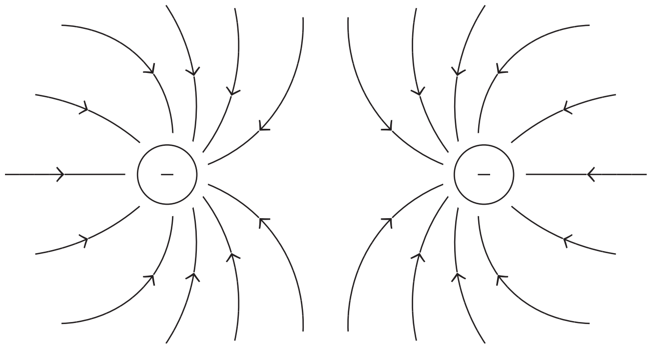
$$F = 2.4 \text{ N}$$

Question 10 A

The speed of light is always c. The invariance of the speed of light is one of the postulates of special relativity.

SECTION B

Question 1 (2 marks)



2 marks
1 mark for the correct shape.
1 mark for the correct direction.

Question 2 (7 marks)

a. Since the velocity of the charge is at right angles to the field, the force will be at right angles to the velocity. 1 mark
The magnitude of the force remains constant regardless of the direction of the charge. 1 mark

b. electron 1 mark
Use the right-hand slap rule, Fleming's left-hand rule or equivalent. 1 mark
The thumb is pointing south, fingers into page and palm to the east. This provides the centre-seeking force for circular motion in the clockwise direction. 1 mark

c. $F = vBq$

$= 1.0 \times 10^{6} \times 0.3 \times 1.6 \times 10^{-19}$ 1 mark

$= 4.8 \times 10^{-14}$ N 1 mark

Question 3 (7 marks)

a. $E = \frac{\Delta V}{d}$

$= \frac{2.00 \times 10^{2}}{5.00 \times 10^{-3}}$ 1 mark

$= 4.00 \times 10^{4}$ V m^{-1} 1 mark

b. $F = qE$

$= 1.5 \times 10^{-6} \times 4.00 \times 10^{4}$ 1 mark

$= 0.060$ N 1 mark

The direction is down. 1 mark

c. $W = Fs$

$= 0.06 \times 2.50 \times 10^{-3}$ 1 mark

$= 1.50 \times 10^{-4}$ J 1 mark

Question 4 (3 marks)

$$F_{\text{right}} = \frac{kQ_1Q_2}{r^2}$$

$$= \frac{9.0 \times 10^9 \times 5.0 \times 10^{-6} \times 10.0 \times 10^{-6}}{2.0^2}$$

$= 0.11$ N 1 mark

$$F_{\text{left}} = \frac{9.0 \times 10^9 \times 5.0 \times 10^{-6} \times 10.0 \times 10^{-6}}{1.0^2}$$

$= 0.45$ N 1 mark

$F_{\text{net}} = 0.34$ N left 1 mark

Question 5 (9 marks)

a. 0 N kg^{-1} 1 mark

The gravitational field vectors from all parts of the mass of Mars point to the centre. 1 mark
These vectors sum to zero. 1 mark

b. $24 \times 60 + 37 = 1477$ min

$= 88\ 620$ s 1 mark

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

$$= \sqrt[3]{\frac{6.67 \times 10^{-11} \times 6.4 \times 10^{23} \times (88\ 620)^2}{4\pi^2}}$$ 1 mark

$= 2.0 \times 10^7$ m 1 mark

d. gravity 1 mark

e. The direction of net force is towards the centre of Mars. 1 mark

Question 6 (5 marks)

a. $F_{\text{AB}} = nBIl$

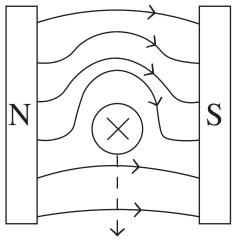
$= 100 \times 0.020 \times 0.50 \times 0.10$ 1 mark

$= 0.10$ N 1 mark

b. $F_{\text{BC}} = 0$ N 1 mark

c. There is a force on the side AB in the position shown because the coil's current travels at right angles to the external magnetic field. 1 mark

By the right-hand rule, the force is downwards on side AB. 1 mark



Note: A diagram that supports the response is acceptable, but not required for the mark.

Question 7 (8 marks)

a. Y to X 1 mark

Change: There is an increasing south field into the coil, therefore a change in flux in the coil. 1 mark

Oppose: A current is induced such that it creates a field with south pole to the left of the coil to oppose the changing in flux of increasing south into the coil. 1 mark

Using the right-hand grip rule, the induced current is from Y to X through the resistor. 1 mark

b. There is no current produced. 1 mark

As there is no changing flux, there is therefore no EMF/current induced in the coil. 1 mark

c. *For example, any two of:*

- Use more coils.
- Use a stronger bar magnet.
- Move the magnet faster relative to the coil.
- Use an iron core.
- Use wires of less resistance.

2 marks

Question 8 (10 marks)

a.

$$\frac{\text{number of turns on the secondary}}{\text{number of turns on the primary}} = \frac{\text{voltage of secondary}}{\text{voltage of primary}}$$

$$= \frac{500}{20}$$ 1 mark

$$= 25$$ 1 mark

b.

$$P = V \times I$$

$$200 \times 10^6 = 500 \times 10^3 \times I$$ 1 mark

$$I = 400 \text{ A}$$ 1 mark

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c. $V_{drop} = I \times R_{lines}$

$= 500 \times 10^3 - 495 \times 10^3$ 1 mark

$= 5 \times 10^3$

$= 400 \times R_{lines}$ 1 mark

$R_{lines} = 12.5\ \Omega$ 1 mark

d. Powerlines have electrical resistance, so the lines use up some of the supplied voltage.
This dissipates power: $P_{loss}\ I^2 r$, so $P_{loss}\ \alpha I^2$. 1 mark
Since $P = VI$, a fixed amount of power of 200×10^6 W can be transmitted at higher voltages to reduce the amount of current flowing through the transmission lines. 1 mark
Reducing the current in the lines by raising the transmission voltage reduces the power loss in the lines while maintaining the power transmitted. 1 mark

Question 9 (5 marks)

a. $v = 34.7\sin(81.7)$

$= 34.3$ 1 mark

$u = 0$, $a = g = 9.8\text{ m s}^{-2}$

$v = u + at$

$34.3 = 0 + 9.8t$ 1 mark

$t = 3.5\text{ s}$ 1 mark

b. distance = speed × time

$= 34.7\cos 81.7 \times 3.5$ 1 mark

$= 17.5\text{ m}$ 1 mark

Note: Consequential on answer to ***Question 9a.***

Question 10 (6 marks)

a. $m_1\boldsymbol{u}_1 + m_2\boldsymbol{u}_2 = m_1\boldsymbol{v}_1 + m_2\boldsymbol{v}_2$

$0.2 \times 20.0 + 0.0 = (0.2 + m) \times 5.0$ 1 mark

$m = 0.6\text{ kg}$ 1 mark

$m = 600\text{ g}$ (as required) 1 mark

b. $E_{K(\text{before})} = \frac{1}{2}m_1(\boldsymbol{u}_1)^2 + \frac{1}{2}m_2(\boldsymbol{u}_2)^2$

$= \frac{1}{2}0.2(20.0)^2 + 0.0 = 40 \text{ J}$ 1 mark

$E_{K(\text{after})} = \frac{1}{2}0.2(\mathbf{5.0})^2 + \frac{1}{2}0.6(\mathbf{5.0})^2 = 10 \text{ J}$ 1 mark

$\frac{1}{2}m_1(\boldsymbol{u}_1)^2 + \frac{1}{2}m_2(\boldsymbol{u}_2)^2 > \frac{1}{2}m_1(\boldsymbol{v}_1)^2 + \frac{1}{2}m_2(\boldsymbol{v}_2)^2$

inelastic 1 mark

Question 11 (7 marks)

a. $U_s = \frac{1}{2} \times 200.0(2.00 - 1.5)^2$ 1 mark

$= 25.0$ J as required 1 mark

b. The ball reaches maximum speed when the net force is zero and the ball has stopped accelerating.

$mg = kx$

$2.0 \times 9.8 = 200.0x$ 1 mark

$x = 0.098 = 0.10 \text{ m}$ 1 mark

c. $E_T = 25.0 \text{ J}$

When launched, the ball has $U_g + E_K$. 1 mark

$25.0 = 2 \times 9.8 \times 0.5 + \frac{1}{2}2 \times v^2$ 1 mark

$v = 3.9 \text{ m s}^{-1}$ 1 mark

Question 12 (5 marks)

a. minimum speed needed to maintain contact:

$g = \frac{v^2}{r}$

$v = \sqrt{9.8 \times 12}$ 1 mark

$= 10.8 \text{ m s}^{-1}$ 1 mark

If the car is travelling at 8.0 m s^{-1} when it reaches the top of the loop it will not remain in contact with the track. 1 mark

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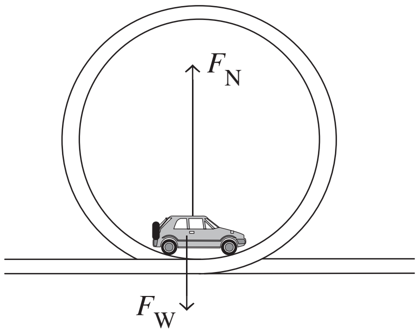
b.



2 marks
1 mark for labelled force vectors.
1 mark for relative length of force vectors.

Question 13 (4 marks)

a. time dilation — 1 mark

b. $l = \frac{l_o}{\gamma}$

$\gamma = \frac{5.0}{2.2} = 2.27$ — 1 mark

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

$= 3.0 \times 10^8 \sqrt{1 - \frac{1}{2.27^2}}$ — 1 mark

$= 2.7 \times 10^8 \text{ m s}^{-1}$ — 1 mark

Question 14 (2 marks)

The work done is equal to the change in kinetic energy.

$\Delta E_K = (\gamma - 1)m_0c^2$

$= (3.2 - 1) \times 9.1 \times 10^{-31} \times (3.0 \times 10^8)^2$ — 1 mark

$= 1.8 \times 10^{-13}$ J — 1 mark