Trial Examination 2019

VCE Physics Unit 3

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

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

Question 1 **No answer as mass is missing from the question**

Question 2 **B**

The right-hand slap rule is used for a positive charge. The thumb is up the page, the fingers are out of the page, the force is to the right. Reverse the direction of the force as it was a negatively charged object. Therefore the direction of the force is to the left.

Question 3 **C or D**

Using the right-hand slap rule, the force on the magnet is upwards. The reading on the scales will be less than 0.500 kg. **But as the Magnet is not properly labelled the force could also be downwards.**

$$F = BIl$$

$$mg = BIl$$

$$m = \frac{BIl}{g}$$

$$\text{reading on the balance} = 0.500 - \frac{BIl}{g}$$

Question 4 **C**

Although the torque decreases in magnitude, the force maintains the same magnitude as PQ is always perpendicular to the field.

Question 5 **B**

When the magnet moves away from the coil, the external flux through the coil is to the left and decreasing. The coil reacts by providing its own flux to the left to account for the loss in external flux (Lenz law). Using the right-hand grip rule, the fingers point inwards and the current (thumb) on the front of the coil pushes upwards. Thus, the current flows from left to right through the resistor by following the wiring conventions.

Question 6 **D**

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

$$F_{\text{D}} - F_f = ma$$

$$F_{\text{D}} - 1500 = 1200 \times 2$$

$$F_{\text{D}} = 2400 + 1500$$

$$= 3900 \text{ N}$$

$$= 3.9 \text{ kN}$$

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Question 7 **D**

$$F_T - F_W = \frac{mv^2}{r}$$

$$F_T = \frac{mv^2}{r} + F_W$$

$$= \frac{1.0 \times 5^2}{0.8} + 9.8 \times 1.0$$

$$= 41.1 \text{ N}$$

Question 8 **C**

The graph shows a smaller force, longer time and same area under curve (for the same change in momentum).

Question 9 **C**

Both Harper and Kate are in an inertial reference frame. They are both stationary in their reference frames and moving in each other's reference frames.

Question 10 **D**

$$1.2 \text{ MeV} = 1.2 \times 10^6 \times 1.6 \times 10^{-19}$$

$$= 1.9 \times 10^{13} \text{ J}$$

$$E = mc^2$$

$$m = \frac{1.9 \times 10^{13}}{(3.0 \times 10^8)^2}$$

$$= 2.1 \times 10^{-30} \text{ kg}$$

$$\text{final mass} = (M - 2.1 \times 10^{-30}) \text{ kg}$$

SECTION B

Question 1 (3 marks)

a. 20 000 N — 1 mark

The opposing force acting on the boat at 1.0 km, for which the net force is zero, is 20 000 N. The boat is travelling at a constant speed, hence the driving force is also 20 000 N.

b.

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

$$F_{\text{D}} - f = ma$$

$$20\,000 - 15\,000 = 5000a$$ 1 mark

$$a = 1.0 \text{ m s}^{-2}$$ 1 mark

Question 2 (8 marks)

a.

$$\cos\theta = \frac{17.32}{20.00}$$

$$\theta = 30.00°$$ 1 mark

$$\sin\theta = \frac{v_{\text{V}}}{20.00}$$

$$v_{\text{V}} = 10.00 \text{ m s}^{-1}$$ 1 mark

Note: Using alternative methods such as Pythagoras' theorem to find v_V is acceptable.

$$v^2 = u^2 + 2as$$

$$0 = 10.0^2 + 2x - 9.8s$$

$$s = 5.1 \text{ m}$$ 1 mark

$$s = 10.0 + 5.1 = 15.1 \text{ m}$$ 1 mark

b. horizontal component: speed = 17.32 m s^{-1}

vertical component (u = 0 m s^{-1}, s = 15.1 m, g = +9.8 m s^{-2}, v = ?):

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

$= 0 + 2 \times 9.8 \times 15.1$ 1 mark

$v = 17.2$ m s^{-1} 1 mark

Then $v = \sqrt{17.3^2 + 17.2^2}$ 1 mark

$= 24.4$ m s^{-1} 1 mark

OR

total mechanical energy$_{\text{TOP}}$ = total mechanical energy$_{\text{BOTTOM}}$

$\frac{1}{2}m(V_\text{T})^2 + mgh_\text{T} = \frac{1}{2}m(V_\text{B})^2$ 1 mark

$\frac{1}{2} \times 20^2 + (9.8 \times 10) = \frac{1}{2}(V_\text{B})^2$ 1 mark

$298 = \frac{1}{2}(V_\text{B})^2$ 1 mark

$V_\text{B} = \sqrt{2 \times 298}$

$= 24.4$ m s^{-1} 1 mark

Question 3 (4 marks)

$\gamma = \dfrac{1}{\sqrt{1 - \dfrac{(0.8c)^2}{c^2}}}$

$= 1.67$ 1 mark

$l = \dfrac{l_\text{O}}{\gamma}$

$l_\text{O} = 6.0 \times 1.67$

$= 10.0$ m 1 mark

$2.9 = \dfrac{10.0}{\gamma}$

$\gamma = 3.45$ 1 mark

$3.45 = \dfrac{1}{\sqrt{1 - \dfrac{(v)^2}{c^2}}}$

$v = 2.87 \times 10^8$ m s^{-1}

$0.96c$ = 96% the speed of light 1 mark

Question 4 (7 marks)

a. $U_g(\text{top}) = U_s(\text{bottom})$ 1 mark

$mgh = \frac{1}{2}ks^2$

$h = s$

$0.1 \times 9.8 \times s = \frac{1}{2} \times 10 \times s^2$ (cancel s) 1 mark

$s = 0.196$ m

$= 19.6$ cm 1 mark

b.

Quantity	Description	Direction
velocity	zero	N/A
net force	maximum	up
kinetic energy	zero	
elastic potential energy	maximum	
gravitational potential energy	minimum	

4 marks

Note: Energy is scalar so no direction is required.
Velocity is zero and, although it is a vector, the direction is N/A.
Award 3 marks for 6 correct answers.
Award 2 marks for 4–5 correct answers.
Award 1 mark for 2–3 correct answers.
Award no marks for 0–1 correct answers.

Question 5 (7 marks)

a. $m_1\boldsymbol{u}_1 + m_2\boldsymbol{u}_2 = m_1\boldsymbol{v}_1 + m_2\boldsymbol{v}_2$ 1 mark

$100x - 5.0 + 90 \times 4 = (100 + 90)v$

$v = -0.74 \text{ m s}^{-1}$

$v = 0.74 \text{ m s}^{-1}$ 1 mark

b. $\Delta p = mv - mu$

$= 100(-0.74 - -5.0)$ 1 mark

$= 426 \text{ kg m s}^{-1}$ 1 mark

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

$= \frac{1}{2}100(-5)^2 + \frac{1}{2}90(4)^2$

$= 1970$ J 1 mark

$\frac{1}{2}m_1(\boldsymbol{v}_1)^2 + \frac{1}{2}m_2(\boldsymbol{v}_2)^2 = \frac{1}{2}100(-0.74)^2 + \frac{1}{2}90(-0.74)^2$

$= 52.0$ J 1 mark

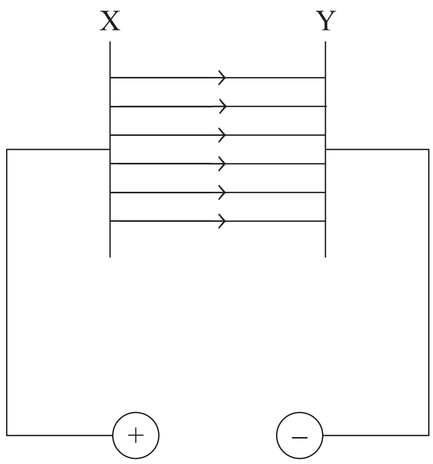
$\frac{1}{2}m_1(\boldsymbol{u}_1)^2 + \frac{1}{2}m_2(\boldsymbol{u}_2)^2 > \frac{1}{2}m_1(\boldsymbol{v}_1)^2 + \frac{1}{2}m_2(\boldsymbol{v}_2)^2$

Therefore it is an inelastic collision. 1 mark

Question 6 (7 marks)

a. An electric field is a region/space/area where a charge experiences an electric force. 1 mark

b.



2 marks

Note: Three to four arrows from X to Y are acceptable.

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

$= \frac{500}{0.010}$ 1 mark

$= 5.0 \times 10^4$ V m^{-1} 1 mark

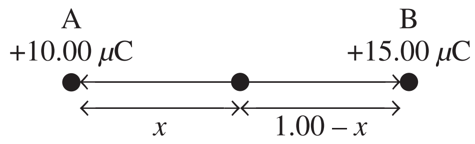
d. $W = Vq$

$= 500 \times 1.6 \times 10^{-19}$ 1 mark

$= 8.0 \times 10^{-17}$ J 1 mark

Question 7 (4 marks)

Let x be the point (as measured from A) where there is no net field and where $E_A = E_B$.



$$E = \frac{kQ}{r^2}$$

$$E_A = \frac{9.0 \times 10^9 \times 1.0 \times 10^{-5}}{x^2}$$ 1 mark

$$E_B = \frac{9.0 \times 10^9 \times 1.5 \times 10^{-5}}{(1.00 - x)^2}$$ 1 mark

$$\frac{9.0 \times 10^9 \times 1.0 \times 10^{-5}}{x^2} = \frac{9.0 \times 10^9 \times 1.5 \times 10^{-5}}{(1.00 - x)^2}$$ 1 mark

$x = 0.45$ m from A towards B 1 mark

Question 8 (6 marks)

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

$$1.6 \times 10^{-19} \times V = \frac{1}{2} \times 9.1 \times 10^{-31}(3.0 \times 10^7)^2$$ 1 mark

$$V = 2559 \text{ V}$$

$$= 2.6 \text{ kV}$$ 1 mark

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

This is found by using the right-hand slap and then reversing your hand because it is an electron. 1 mark

c. $$F = \frac{mv^2}{r}$$

$$= 9.1 \times 10^{-31} \times (3.0 \times 10^7)^2$$ 1 mark

$$= 8.2 \times 10^{-15} \text{ N}$$ 1 mark

Question 9 (7 marks)

a. $T = \sqrt{\dfrac{4\pi^2 r^3}{GM}}$ 1 mark

$= \sqrt{\dfrac{4\pi^2(6.4 \times 10^6 + 400 \times 10^3)^3}{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}}$ 1 mark

$= 5.6 \times 10^3$ s 1 mark

b. $v = \sqrt{\dfrac{GM}{r}}$

$= \sqrt{\dfrac{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}{(6.4 \times 10^6 + 400 \times 10^3)}}$ 1 mark

$= 7.7 \times 10^3$ m s^{-1} 1 mark

c. No. 1 mark

The velocity of the orbit is independent of the mass of the object in orbit.

$v = \sqrt{\dfrac{GM}{r}}$

The mass of the satellite is not in the equation for speed. 1 mark

Question 10 (8 marks)

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

This is when UV is parallel to the magnetic field. 1 mark

b. $I = \dfrac{V}{R}$

$= \dfrac{12.0}{6.0}$ 1 mark

$= 2.0$ A 1 mark

$F = nBIl$

$= 1 \times 20 \times 10^{-3} \times 0.1 \times 2.0$ 1 mark

$= 4.0 \times 10^{-3}$ N 1 mark

c. *Any two of the following:*

- Increase the voltage/current.
- Use a coil with many turns of wire (this motor has only one).
- Increase the length of TU.
- Use a magnet with a stronger magnetic field.
- Curve the poles of the magnet.
- Reduce the resistance of the wire.

2 marks

Question 11 (4 marks)

The current flows in an clockwise direction. 1 mark

Change: There is an increasing field out of the page and therefore a change in external flux in the coil. 1 mark

Oppose: The coil opposes this increase by providing its own flux into the page. 1 mark

Direction: As the induced flux is into the page the current must be flowing in the wire in a clockwise direction (from the right hand grip rule) 1 mark

Question 12 (8 marks)

a. The slip rings are permanently connected to the same sides of the coil. 1 mark

The induced current in the coil alternates in direction. 1 mark

The slip rings carry this alternating current to the external circuit. 1 mark

b. $T = \frac{1}{50}$

$= 0.02$

$T\left(\frac{1}{4}\right) = \frac{0.02}{4}$

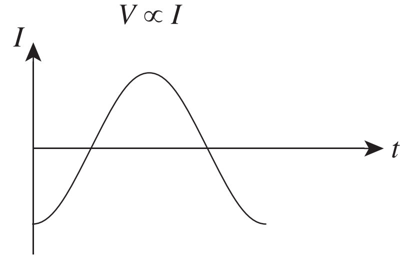
$= 0.005$ 1 mark

$\text{EMF} = \frac{N\Delta\phi}{\Delta t}$

$= 50\frac{(0 - 0.2 \times 0.02)}{0.005}$ 1 mark

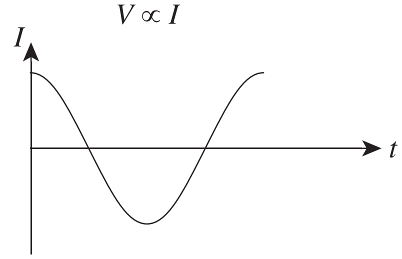
$= 40.0 \text{ V}$ 1 mark

c. $V \propto I$



OR

$V \propto I$



2 marks

1 mark for shape of graph.

1 mark for current being a maximum amplitude at T = *0.*

Question 13 (7 marks)

a. The power across the transformer is the same: 300 MW.

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

$$= \frac{300 \times 10^6}{600 \times 10^3}$$ 1 mark

$$= 500 \text{ A}$$ 1 mark

b. $$\frac{\text{number of turns in the secondary windings}}{\text{number of turns in the primary windings}} = \frac{600 \text{ kV}}{30 \text{ kV}}$$ 1 mark

$$= 20$$ 1 mark

c. $$V_{\text{primary coil of the step-down transformer}} = V_{\text{secondary coil of the step-up transformer}} - V_{\text{drop across lines}}$$

$$= 600\,000 - 500 \times 5$$ 1 mark

$$= 597\,500 \text{ V}$$ 1 mark

$$= 598 \text{ kV}$$ 1 mark

