Neap:

PHYSICS VCE UNITS 3&4
DIAGNOSTIC TOPIC TESTS 2017

TEST 2: HOW DO THINGS MOVE WITHOUT CONTACT? (II)

SUGGESTED SOLUTIONS AND MARKING SCHEME

Question 1 (11 marks)

a. $r_{\text{orbit}} = \text{altitude} + r_{\text{Earth}}$

$= (400 \times 10^3) + (6.38 \times 10^6)$

$= 6.78 \times 10^6 \text{ m}$ 1 mark

b. $g = \dfrac{GM_{\text{Earth}}}{r^2}$ or $g = \dfrac{F_{\text{Earth}}}{M_{\text{ISS}}}$

$g = \dfrac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{(6.78 \times 10^6)^2}$ 1 mark

$= 8.68 \text{ N kg}^{-1}$ 1 mark

*Note: Consequential on answer to **Question 1a.***

c. $W = F_{\text{gravity}}$

$= \dfrac{GM_{\text{Earth}}M_{\text{ISS}}}{r_{\text{orbit}}^2}$

$= \dfrac{6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times 4.20 \times 10^5}{(6.78 \times 10^6)^2}$ 1 mark

$= 3.64 \times 10^6 \text{ N}$ 1 mark

*Note: Consequential on answer to **Question 1a.***

d. $\dfrac{r_{\text{orbit}}^3}{T^2} = \dfrac{GM_{\text{Earth}}}{4\pi^2}$

$$T = \left(\frac{4\pi^2 \times (6.78 \times 10^6)^3}{6.67 \times 10^{-11} \times 5.98 \times 10^{24}} \right)^{\frac{1}{2}}$$ 1 mark

$= 5553.14$ sec

$= \dfrac{5553.14}{60}$ min 1 mark

$= 92.5$ min 1 mark

Note: Consequential on answer to ***Question 1a.***

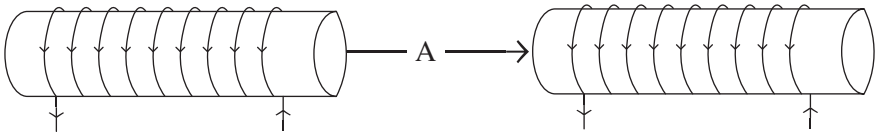
e. The astronauts and their craft are in orbit about the Earth and so accelerate toward the Earth.

They have **weight** due to the Earth's gravity acting upon them keeping them in circular motion. 1 mark

They do not make contact with the craft and so do not experience any **normal reaction** forces. 1 mark

Thus, they are apparently weightless and not truly weightless. 1 mark

Question 2 (8 marks)

a. 

1 mark

b. The left coil has a field at A due to the right hand grip rule (thumb → positive current, curl of fingers → magnetic field). The field is to the right and an N end is produced at A. 1 mark

The right coil has an S end on its left side due to the right hand grip rule and so its field is also to the right. 1 mark

The sum of the two individual fields produces a net field to the right, shown by the bold arrow. 1 mark

c. Rotating the left coil, for example, reverses the current orientation and the field of the coil. 1 mark

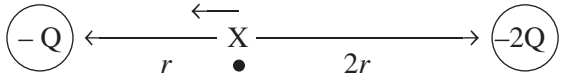
The two individual fields at A will be equal in value but opposite and so will cancel to give a net magnetic field of zero. 1 mark

d. Decreasing the current reduces the field strength at A for one of the coils. 1 mark

Thus the net field at A is also reduced in magnitude as it is the sum of the two fields from the coils. The net field is still to the right. 1 mark

Question 3 (4 marks)

a.



1 mark

E_Q at $X = \dfrac{kQ}{r^2}$ (left)

E_{-2Q} at $X = \dfrac{k2Q}{(2r)^2}$

$= \dfrac{kQ}{2r^2}$ (right)

The field due to –Q is greater and so net field is left.

b. The field due to $-Q$ is now $E = \dfrac{-kQ}{(4r)^2}$

$= \dfrac{-kQ}{16r^2}$ (left)

The field due to $-2Q$ is $E = \dfrac{-2kQ}{(2r)^2}$

$= \dfrac{-kQ}{2r^2}$ (right) 1 mark

The magnitude of the electric field due to $-2Q$ is now eight times greater than that of $-Q$ 1 mark
and so the resultant electric field is to the right. 1 mark

Question 4 (3 marks)

$F = NBIl\sin\theta$

$= 5 \times 9.0 \times 10^{-2} \times 2.0 \times 0.50 \times \sin 90°$ 1 mark

$= 0.45$ N 1 mark

Direction is determined by the right hand palm rule.

thumb → positive current (right)

fingers → external magnetic field (into page)

out of palm of hand → force acting on wires (up the page) 1 mark

Question 5 (12 marks)

a. The current in the arm JK is into page. The current in the arm LM is out of the page. 1 mark

Using the right hand palm rule, (thumb → current, fingers → magnetic field, palm out → force) the forces are down on side JK and up on side LM. 1 mark

The motor turns anticlockwise 1 mark

b. The commutator consists of a ring split into two halves.

A coil end touches each half ring.

As the coil turns, the ends of the coil disconnect and reconnect to the opposite half ring. This occurs every half cycle and reverses the direction of the current relative to the coil. 1 mark

This, in turn, reverses the force direction acting on the sides JK and LM every half cycle. 1 mark

This is important to maintain continuous rotation in the same direction. 1 mark

c. **1.** Reverse the battery polarity so that, relative to an observer, current direction is reversed from the original direction. 1 mark

2. Reverse the positions of the N and S poles of the magnets. 1 mark

d. $F = NBIl\sin\theta$

$= 500 \times 0.50 \times 0.400 \times 0.20 \times \sin 90°$ 1 mark

$= 20$ N 1 mark

e. $F = NBIl\sin 0°$

$= 0$ (That is, current and magnetic field are parallel.) 1 mark

Hence $F = 0$ N 1 mark

Question 6 (4 marks)

a. qV = electrical energy used = E 1 mark

$$V = \frac{\text{energy}}{q}$$

$$= \frac{8.0 \times 10^{-9}}{1.6 \times 10^{-19}}$$

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

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

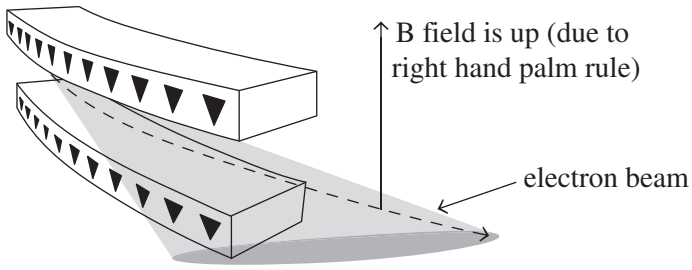
$$= \frac{5.0 \times 10^{10}}{3.2 \times 10^{3}}$$ 1 mark

$= 1.6 \times 10^{7}$ V m^{-1} 1 mark

Note: Consequential on answer to ***Question 6a.***

Question 7 (3 marks)

a.



1 mark

b. The electron beam current is equivalent to a positive current going in the opposite direction. 1 mark

Using the right hand grip rule with thumb → ⊕ current, force → into centre of circle, fingers → represent the magnetic field going upwards. 1 mark