Neap

Trial Examination 2021

Suggested solutions

QCE Physics Units 3&4

Paper 2

SECTION 1

QUESTION 1 (3 marks)

Using Kepler's third law:

$$\frac{r^3}{T^2} = \frac{GM_{\text{Sun}}}{4\pi^2} = \text{constant} = \text{gradient}$$

$$\text{gradient} = \frac{50.0 \times 10^{36}}{15.0 \times 10^{18}}$$

$$= 3.33 \times 10^{18}$$ *[1 mark]*

$$M_{\text{Sun}} = \frac{4 \times \pi^2 \times 3.33 \times 10^{18}}{6.67 \times 10^{-11}}$$ *[1 mark]*

$$= 1.97 \times 10^{30} \text{ kg}$$ *[1 mark]*

QUESTION 2 (8 marks)

a) The photon is an indivisible packet of light of any energy or frequency that is either fully absorbed by an electron or is not absorbed at all during the photoelectric effect experiment. *[1 mark]*

For an electron to be emitted, the absorbed photon must have an energy at least equal to the work function of the metal (minimum energy needed). *[1 mark]*

Thus, the photon energy (*hf*) must be at least equal to the work function *W* such that a minimum frequency (*x*-axis intercept) of the wave that constitutes the photon is required. *[1 mark]*

When the photon frequency is less than this minimum frequency (4.5×10^{14} Hz from the graph), no electrons are released and so require no stopping potential. *[1 mark]*

When the photon frequency is greater than or equal to this minimum frequency and these photons are absorbed, electrons are released with their kinetic energy equal to the difference between the photon energy and the work function. The greater the difference, the greater the electron kinetic energy and so a greater stopping potential is required, varying linearly with the photon frequency. *[1 mark]*

b) $$2.4 \times 10^{-19} = \frac{2.4 \times 10^{-19}}{1.6 \times 10^{-19}}$$ *[1 mark]*

$$= 1.5 \text{ eV}$$

1.5 eV corresponds to a stopping voltage of 1.5 V. *[1 mark]*

From the graph, 1.5 eV corresponds to 8.0×10^{14} Hz. *[1 mark]*

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QUESTION 3 (6 marks)

a) The horizontal speed is constant throughout the motion.

$$\text{horizontal speed} = \frac{\text{horizontal distance}}{\text{flight time}}$$

$$= \frac{4.64}{1.00}$$

$$= 4.64 \text{ m s}^{-1}$$ *[1 mark]*

$$\text{launch speed} = \frac{\text{horizontal speed}}{\cos(22)}$$

$$= \frac{4.64}{0.927}$$ *[1 mark]*

$$= 5.0 \text{ m s}^{-1}$$ *[1 mark]*

b) The height above ground can also be represented as the vertical displacement from the launch.

Take upwards as positive.

From the information provided, the known values are $a_v = -9.8$, $u_v = 5.0\sin(22)$ and $t = 1.0$ s. *[1 mark]*

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

$$= \left(5.0\sin(22) \times 1.0\right) + \left(\frac{1}{2} \times -9.8 \times 1.0^2\right)$$ *[1 mark]*

$$= 1.873 - 4.9$$

$$= -3.03$$

$\therefore h = 3.0$ m *[1 mark]*

Note: Consequential on answer to Question 3a).

QUESTION 4 (5 marks)

a) As object M accelerates downwards, it experiences a net force downwards. *[1 mark]*

Since the net force is equal to F_g minus tension, the tension must be less than F_g in magnitude. *[1 mark]*

b) Both masses experience the same acceleration in their forward directions.

Use $\sum F = ma$.

For object M: mg – tension = ma (1)

For the 500 g object: tension – 0.500 g = 0.500a (2)

[1 mark]

Note: Award 1 mark for equations (1) and (2).

9.8m – tension = 1.8m (1)

tension – 4.9 = 0.9 (2)

[1 mark]

Note: Award 1 mark for equations (1) and (2).

From (2): tension = 5.8 N

From (1): 8.0m = tension

Hence, 8.0m = 5.8.

$$m = \frac{5.8}{8.0}$$
$$= 725\ g$$

[1 mark]

QUESTION 5 (3 marks)

For the instant shown, the coil experiences maximum flux into the page. As the coil is pulled to the right and out of the magnetic field, it experiences a decrease in flux into the page. *[1 mark]*

The coil opposes the reduction in external flux by providing its own flux through the coil into the page. *[1 mark]*

Using the right-hand rule, with the hand placed on the bottom horizontal part of the coil, the fingers (representing magnetic field) point into the page through the coil, and the thumb (representing current) points to the left.

The direction of the current as seen from the view of the diagram is clockwise. *[1 mark]*

QUESTION 6 (6 marks)

As observer B is always equidistant from lights X and Y, the light from each takes the same time to travel the same distance (the speed of light). Thus, observer B concludes that the lights are turned on simultaneously. *[1 mark]*

For observer A, the speed of light is the same constant value as for observer B. *[1 mark]*

Due to the velocity of the train to the right of observer A, the light from X to observer A travels a greater distance than the light from Y to Observer A. *[1 mark]*

Hence, as the light travels at a constant speed in all directions, the light from X takes a longer time to reach observer than the light from Y. *[1 mark]*

As observer A concludes that the lamps do not turn on simultaneously, the two different conclusions conflict and may appear to be paradoxical. *[1 mark]*

However, while the observations and conclusions are different for the two observers, they are true in their frames of reference. The observations are not paradoxical. *[1 mark]*

QUESTION 7 (3 marks)

Let the identity of light be a series of crests and troughs as in a transverse wave. Light waves pass through both slits and diffract (spread out) between the plane of the slits and the screen. *[1 mark]*

When the waves from both slits meet such that a crest from one slit arrives at the same point and same time as a crest from the other slit (or equivalently, the troughs), they interfere constructively to form a bright spot. *[1 mark]*

When the waves from both slits meet such that a trough from one slit arrives at the same point and same time as a crest from the other slit, they interfere destructively to form a dark spot. *[1 mark]*

QUESTION 8 (6 marks)

a) Lorentz factor:

$$\gamma = \frac{1}{\sqrt{1-0.95^2}}$$

$$= 3.20$$ *[1 mark]*

The proton's reference frame would measure a smaller (contracted) distance compared to that measured by the physicist. This is equivalent to the physicist measuring a dilated time compared to the proton's frame. Thus, the time interval in the proton's frame is a lesser value given by:

$$\frac{t}{\gamma} = \frac{1.75\times10^{-7}}{3.20}$$

$$= 5.47\times10^{-8}\ \text{s}$$ *[1 mark]*

Distance travelled by the proton in its own frame of reference:

$$\text{distance} = 0.95\times3.0\times10^{8}\times5.46\times10^{-8}$$ *[1 mark]*

$$= 15.6\ \text{m}$$ *[1 mark]*

b) $$p = m_0 v\gamma$$

$$= 1.67\times10^{-27}\times0.95\times3.0\times10^{8}\times3.20$$ *[1 mark]*

$$= 1.5\times10^{-18}\ \text{kg m s}^{-1}$$ *[1 mark]*

QUESTION 9 (5 marks)

a) $$\phi = B\times A$$

$$= 0.20\times(0.060\times0.040)$$ *[1 mark]*

$$= 0.00048$$

$$= 4.8\times10^{-4}\ \text{Wb}$$ *[1 mark]*

b) $$\text{emf} = \frac{n\Delta(BA)}{t}$$ *[1 mark]*

$$= \frac{20\times\text{answer to part a)}}{2.0}$$ *[1 mark]*

$$= \frac{20\times0.00048}{2.0}$$

$$= 4.8\times10^{-3}\ \text{V}$$ *[1 mark]*

Note: Consequential on answer to Question 9a).