Tampines Meridian Junior College

2025 JC2 H2 Physics Preliminary Examination Paper 2

Suggested Solution

1 **(a)**

$$\mu = \frac{ve}{F}$$

$$[\mu] = \frac{[v][e]}{[F]}$$

$$= \frac{\text{m s}^{-1}\ \text{(C)}}{\text{N}} \qquad \text{[M1]}$$

$$= \frac{\text{m s}^{-1}\ \text{(A s)}}{\text{kg m s}^{-2}}$$

$$= \text{A kg}^{-1}\ \text{s}^{2} \qquad \text{[A1]}$$

−1 if use C and/or N

−1 if poor presentation

(b) **(i)** Zero error or wrongly calibrated scale [B1]

(ii) Reading scale from different angles [B1]

Must explain if write parallax error.

(c) **(i)**

$$R_X = \frac{V}{I} = \frac{3.00}{4.9 \times 10^{-3}} \qquad \text{[B1]}$$

$$= 612\ \Omega$$

(ii)

$$\frac{\Delta R_X}{R_X} = \frac{\Delta V}{V} + \frac{\Delta I}{I}$$

$$\frac{\Delta R_X}{612} = \frac{0.03}{3.00} + \frac{0.1}{4.9}$$

$$\Delta R_X = 20\ \Omega \qquad \text{[M1]}$$

$$R_X \pm \Delta R_X = 610 \pm 20\ \Omega \qquad \text{[A1]}$$

(d) When plotting a graph, a best fit line shows the average trend of the data points, thus <u>reducing random error</u> present. Those readings which are too far out from the graph are not taken into account so the results will be more reliable. [B1]

OR

By using multiple sets of values and plotting them on a graph, any consistent deviation from the expected trend can be observed. If all points lie away from the expected line or curve in a similar manner, this may indicate the <u>presence of a systematic error</u>.

OR

When several data points are collected and plotted, it becomes easier to <u>identify anomalous readings</u> (readings that deviate significantly from the general pattern or trend). These readings are not taken into account so the mean value of resistance of X will be closer to the actual value..

2 **(a)** At top of trajectory, <u>vertical component of velocity is zero</u> and horizontal component of velocity is constant, hence it will have minimum KE [B1]
or
At top of trajectory, <u>gravitational potential energy of object is greatest</u> hence kinetic energy is the lowest since only 2 forms of energies are involved. [B1]

(b) Min KE is when object is at the highest point with only horizontal velocity.
½ m v_x^2 = 12.5 J

$v_x = u_x = \sqrt{\dfrac{12.5}{0.5\times0.25}} = 10 \text{ ms}^{-1}$ [M1]

$u\cos 40^o = 10$ [M1]

$u = 13 \text{ ms}^{-1}$ [A0]

(c) **(i)** $s_y = u_y t + \dfrac{1}{2}at^2$

taking upwards as positive,

$-100 = 13\sin 40^o t + \dfrac{1}{2}(-9.81)t^2$ [C1]

$t = -3.74$ s (rej) or $t = 5.45$ s [A1]

(ii) $s_x = u_x t = 10(5.45) = 55$ m [A1] allow ecf

(iii) $v_y = u_y + at$

taking upwards as positive,

$v_y = 13\sin 40° + (-9.81)(5.45) = -45.1 \text{ m s}^{-1}$ [C1]

$v = \sqrt{(45.1)^2 + (10)^2} = 46 \text{ m s}^{-1}$ [A1]

$\theta = \tan^{-1}(\dfrac{45.1}{10}) = 77°$ (clockwise) below horizontal [A1]

3 **(a)** It is due to the difference in pressure between the bottom surface and top surface. [B1]

(b)(i) $W = mg$

$= V_o \rho_o g$ [B1]

(b)(ii) $U = V_o \rho_f g$ [B1]

(c) In order to sink,

$W > U$ [M1]

$V_o \rho_o g > V_o \rho_f g$

$\rho_o > \rho_f$ [A1]

(d) As the (downward) velocity of the object increases, the (upward) <u>drag force (or fluid resistance) is increasing</u>. [B1]

Hence the downward <u>acceleration (or net force) decreases</u>. [B1]
(also accept: hence the velocity increases at a decreasing rate)

When the (sum of) <u>drag force and upthrust is equal to the weight</u> [B1]
The net force is zero and acceleration is zero, resulting in terminal velocity.

4 **(a)** Consider the top most position.

When the angular speed is just enough for person to stay in contact with the wall, person is about to lose contact with the wall.

As such, normal contact force = 0 at top most position

Component of weight parallel to floor of cylinder provides for the centripetal force [B1]

$mg \sin\theta = \mathrm{m}r\omega^2$

$(9.81)\sin 50° = (8.0)\omega^2$ [M1]

$\omega = 0.97 \text{ rad s}^{-1}$ [A0]

(b) At the bottom most position,

The resultant of the normal contact force from wall and component of weight parallel to floor provides for the centripetal force.

$N_{wall} - mg \sin\theta = \mathrm{m}r\omega^2$ [C1]

$N_{wall} = (65)(8.0)(0.97)^2 + (65)(9.81)\sin 50°$

$N_{wall} = 980 \text{ N}$ [A1]

(c) Gain in gravitational potential energy

$= 65(9.81)(2 \times 8.0 \times \sin 50°)$ [C1]

$= 7800 \text{ J}$ [A1]

(d) Average power

$= \dfrac{\text{work done}}{\text{time}}$

$= \dfrac{\text{gain in gravitational potential energy}}{\text{time}}$

$= \dfrac{7800}{\frac{1}{2}\left(\frac{2\pi}{0.97}\right)}$ [C1]

$= 2400 \text{ W}$ [A1]

Allow ecf from (c)

5 **(a)** Simple harmonic motion is defined as the motion of a particle about a fixed point such that its acceleration is proportional to its displacement from the fixed point and is directed towards the point (or opposite in direction to the displacement). [B1]

(b) $p = mv$ -------- (1)

$E_K = \frac{1}{2}mv^2$ -------- (2) [C1 for both (1) & (2)]

sub (1) into (2)

$$E_K = \frac{p^2}{2m}$$

$$m = \frac{p^2}{2E_K}$$

$$= \frac{0.72^2}{2(0.86)} \qquad \text{[M1]}$$

$$= 0.30 \text{ kg} \qquad \text{[A0]}$$

(c) **(i)**

$$T_{\text{rod}} = T_{\text{pendulum}}$$

$$\frac{1}{0.55} = 2\pi\sqrt{\frac{L}{9.81}} \qquad \text{[M1]}$$

$$L = 0.82 \text{ m} \qquad \text{[A1]}$$

(ii)

$$\Delta\phi = \frac{\Delta t}{T}(2\pi)$$

$$= \frac{0.50}{1.82}(2\pi)$$

$$= 1.73 \text{ rad} \qquad \text{[B1]}$$

(d) **(i)** Damping due to viscous forces [B1]

(ii)

$$E_{\text{total}} = \frac{1}{2}m\omega^2 {x_o}^2$$

$$= \frac{1}{2}m\left(\frac{2\pi}{T}\right)^2 {x_o}^2$$

$$E_f - E_i = \frac{1}{2}m\left(\frac{2\pi}{T}\right)^2 \left({x_{o_f}}^2 - {x_{o_i}}^2\right)$$

$$= \frac{1}{2}(0.30)\left(\frac{2\pi}{1.05 \times 2}\right)^2 (0.016^2 - 0.020^2) \qquad \text{[M1]}$$

$$= -1.93 \times 10^{-4} \text{ J}$$

decrease in $E = 1.93 \times 10^{-4}$ J [A1]

6 **(a)** From graph, resistance = 1.85 Ω

(b) Effective resistance of the 4 components:

$$R_{eff} = \left[\frac{1}{2.5+3.6} + \frac{1}{1.85+4.5}\right]^{-1} = 3.111\,\Omega \quad \text{[C1 for working]}$$

Hence, terminal p.d.:

$$V_{\text{terminal}} = \left(\frac{3.111}{3.111+0.70}\right)6.0 \quad \text{[M1]}$$

$$= 4.9\text{ V} \quad \text{[A0]}$$

Alternative:

$$I = \frac{V}{R_{total}} = \frac{6.0}{3.111+0.70} = 1.5744\text{ A}$$

$$V_{\text{terminal}} = E - Ir$$

$$= 6.0 - (1.5744)(0.70) \quad \text{[M1]}$$

$$= 4.9\text{ V}$$

(c)

$$I = \frac{V_{\text{terminal}}}{1.85+4.5}$$

$$= \frac{4.9}{1.85+4.5} \quad \text{[M1]}$$

$$= 0.771\text{ A} \quad \text{[A1]}$$

(d)

$$V_{\text{thermistor}} = IR_T = (0.771)(1.85) = 1.43\text{ V} \quad \text{[B1]}$$

OR

$$V_{\text{thermistor}} = \frac{1.85}{1.85+4.5}(4.9) = 1.43\text{ V} \quad \text{[B1]}$$

(d) For the galvanometer to read zero, the potentials at C and D must be the same (i.e. no p.d. between C and D).
For p.d. across CD to be zero,

$$V_{AC} = V_{\text{thermistor}}$$

$$V_{AB} = \left(\frac{2.5}{2.5+3.6}\right)(4.9) = 2.008\text{ V} \quad \text{[C1 for working to show } V_{AC} = V_{\text{thermistor}}\text{]}$$

$$\frac{V_{AC}}{V_{AB}} = \frac{L_{AC}}{L_{AB}}$$

$$L_{AC} = \frac{V_{AC}}{V_{AB}} \times L_{AB} = \frac{1.43}{2.008}(1.0) = 0.71\text{ m} \quad \text{[A1]}$$

OR

For p.d. across CD to be zero,

$V_{AC} = V_{\text{thermistor}}$

$\left(\dfrac{R_{AC}}{2.5+3.6}\right)(4.9) = 1.43$ [C1 for working to show $V_{AC} = V_{\text{thermistor}}$]

$R_{AC} = 1.776\ \Omega$

$L_{AC} = \dfrac{1.776}{2.5}(1.0) = 0.71\text{ m}$ [A1]

7 **(a)** **(i)** Number of protons = 57, number of neutrons = (141 – 57) = 84 [B1]

(ii) Mass defect, $\Delta m = \left[(141-57)(1.009)+57(1.007)-140.911\right]$ [M1]

$= 1.244\left(1.66\times10^{-27}\right)$

$= 2.06504\times10^{-27}$ kg

Binding energy $= \Delta mc^2$

$= \left(2.06504\times10^{-27}\right)\left(3.00\times10^{8}\right)^2$ [M1]

$= 1.858536\times10^{-10}$ J [M1]

$= 1161.585$ MeV

$= 1162$ MeV [A0]

(iii) B.E. per nucleon of Pu-239 $= \dfrac{1807}{239}$

$= 7.56$ MeV

B.E. per nucleon of La-141 $= \dfrac{1162}{141}$

$= 8.24$ MeV [M1: for both energies]

Since plutonium-239 nucleus has a lower binding energy per nucleon, it is less stable against fission [B1]

and is more likely to undergo nuclear fission. [A1]

(b) **(i)** ${}^{141}_{57}\text{La} \rightarrow {}^{141}_{58}\text{Ce} + {}^{0}_{-1}\beta$

Electron or beta particle [B1]

(ii) There is emission of a neutrino (or anti-neutrino, or third particle) along with an electron. [M1]

The energy/momentum is shared between the electron and neutrino (anti-neutrino) in various ways (or such that the neutrino also has a range of energy/momentum), while maintaining conservation of energy and momentum. [A1]

Hence the electrons and neutrinos are emitted with a range of energies.

8 **(a)** The dense core emits white light [1]
As the white light passes through the cooler gas layer, photons of energy corresponding to the energy level differences in the gas are absorbed [1]

(b) Since the wavelength corresponding to Hydrogen are darker/thicker [1]
There is more hydrogen than helium [1]

(c) Since there are more lines present in Fig 8.1 than there are present in Fig 8.2 and 8.3, [M1 – comparing the spectra]

These lines are likely caused by other gases. [A1 – other lines indicate other gases]

(d) **(i)** $c = f\lambda$

$$f = \frac{3\times10^{8}}{410\times10^{-9}} \quad [\text{B1}]$$

$$= 7.3\times10^{14} \text{ Hz}$$

(ii) $E = hf$

$$= \left(6.63\times10^{-34}\right)\left(7.3\times10^{14}\right) \quad [\text{M1}]$$

$$= 4.84\times10^{-19} \text{ J} \quad [\text{A1}]$$

(e) **(i)**

Hydrogen spectral wavelengths from GN-Z11 / nm	Hydrogen spectral wavelengths from stationary source on Earth / nm	z	v / m s^{-1}
676	656	0.0305	9.15×10^{6}
500	485	0.0309	9.27×10^{6}

$$z = \frac{500-485}{485} = 0.0309$$

$$v = 0.0309\times\left(3.0\times10^{8}\right)$$

$$= 9.27\times10^{6} \text{ m s}^{-1}$$

[B1 per cell]

(ii) Since the wavelengths become longer,
They are closer to the red end of the visible spectrum [B1]
Hence they are called “red-shift”

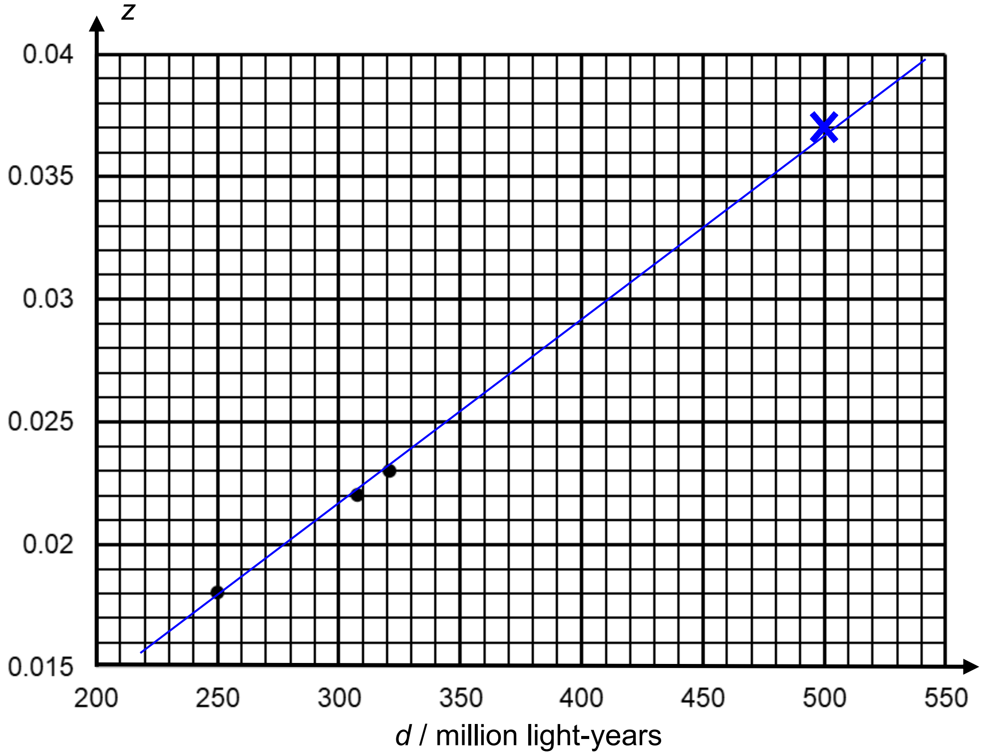
(iii) The Andromeda Galaxy is moving toward Earth.

(f) **(i)** $\text{one lightyear} = 365\times24\times60\times60\times\left(3.0\times10^{8}\right)$

$$= 9.46\times10^{15} \text{ m}$$

(ii) The further the galaxy, the faster it is moving away from the Earth.

(iii)



Plot [B1]
Best fit line [B1]

(iv) Using (0.039, 530) and (0.018, 250)

$$\frac{H_o}{c} = \frac{(0.039 - 0.018)}{(530 - 250) \times (9.46 \times 10^{15} \times 10^{6})}$$

$$= 7.93 \times 10^{-27} \quad [\text{C1}]$$

$$H_o = (3 \times 10^{8})(7.93 \times 10^{-27}) \quad [\text{C1}]$$

$$= 2.38 \times 10^{-18} \quad [\text{A1}]$$