RVHS JC2 H2 Physics Preliminary Examinations Paper 3 Mark Scheme

1 **(a)** Distance travelled before hitting the ground = Area under graph from 0 to 0.6 s. M1

= ½ (4 + 10) * 0.60 = 4.2 m A1

(b) Distance that the ball bounce upwards M1
= ½ (1.0 * 10.0) = 5.0 m

Height above original = 0.8 m A1

(c) Acceleration = 10/1.0 = 10 m s^{-2} A1

(d) Time taken to travel upwards = time taken to travel downwards
Next time the ball will reach ground = 2.6 s A1

2 **(a)** **(i)** conservation of linear momentum gives C1

$$10m + 2(5m) = mv + 4.5(5m)$$

$v = -2.5$ m s^{-1} A1

(ii) kinetic energy before collisioin $\frac{1}{2}m10^2 + \frac{1}{2}(5m)2^2 = 60m$ B1

kinetic energy after collision $\frac{1}{2}m(-2.5)^2 + \frac{1}{2}(5m)4.5^2 = 53.75m$ B1

percentage loss = $\frac{60-53.75}{60} \times 100\% = 10\%$ B1

(b) conservation of momentum gives B1
$10m + 2(5m) = mv_1 + (5m)v_2$ -------(1)

for elastic collsion, relative speed of approach = relative speed of separation. So $10 - 2 = v_2 - v_1$-------- (2) B1

Or conservation of kinetic energy gives
$\frac{1}{2}m2^2 + \frac{1}{2}(5m)2.0^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}(5m)v_2^2$ -------(2)
solving simultaneous (1) and (2) M1
$v_1 = -3.3$ m s^{-1} , $v_2 = +4.7$ m s^{-1} A1

3 **(a)** loss in gravitational potential energy = gain in kinetic energy + gain in elastic potential energy B1

(b) **(i)** $4.0 \times 9.81 \times 0.090 = \frac{1}{2} \times 200 \times 0.09^2 + E_k$ B1
$E_k = 2.7$ J B1

(ii) Since both blocks have same acceleration and hence same velocity, $E_k \propto m$ M1
So taking ratio, $\frac{E_{k,Q}}{E_k} = \frac{4}{6}$

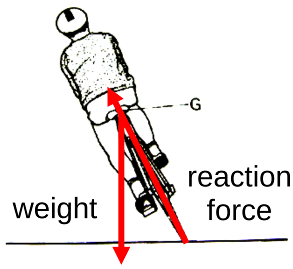
or other appropriate method
$E_k = 1.8$ J A1

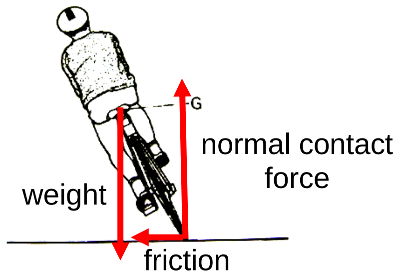
(c) When blocks come to rest $E_k = 0$. Let distance required by x, then conservation of energy gives

$$4 \times 9.81 \times x = \frac{1}{2} \times 200 \times x^2$$ M1

$x = 39$ cm A1

4 **(a)**





B1
B1

1 mark for correct direction of arrows
1 mark for similar length of arrows in vertical direction

(b) Since frictional force provides for the centripetal force,

$$f = \frac{mv^2}{R}$$

$$70 = \frac{(80)v^2}{55}$$ C1

$$v = 6.9 \text{ m s}^{-1}$$ A1

(c) **(i)** For a surface which is banked, the horizontal component of the normal reaction is an <u>additional source of the centripetal force</u>. B1

Since <u>Centripetal Force = $\frac{mv^2}{r}$</u>, an increase in the centripetal force would allow the rider to turn the corner at a higher speed without slipping, provide the <u>mass of cyclist and bicycle and radius of turn remain constant.</u> B1

(ii) Considering forces acting on the rider/bicycle in the horizontal direction:

$$N \sin 20° + f \cos 20° = \frac{mv^2}{r} \quad \text{---------------------- (1)}$$

For the equilibrium in the vertical direction:

$$N\cos 20° = mg + f \sin 20° \quad \text{--------------------(2)}$$

C1 for both

Solving (1) & (2),

$$\tan 20° \left(mg + f \sin 20°\right) = \frac{mv^2}{r} - f \cos 20°$$ C1

→max velocity during turning v = 15.7 m s^{-1} A1

5 **(a)** **(i)** A = 3.00 B1

$\omega = 2\pi / T = 2\pi / 0.785 = 8.00$ B1

$x = A\cos(\omega t - B)$

$2.00 = 3.00\cos(8.00(0) - B)$

$B = 0.841$ B1

(ii) Maximum velocity = ωx_0 = (8.00)(3.00) = 24.0 A1

Maximum acceleration = $\omega^2 x_0$ = $(8.00)(3.00)^2$ = 192 A1

(iii) $\frac{1}{2} m v_{max}^2 = \frac{1}{2} m \omega^2 x_0^2$

$= \frac{1}{2}(5.0 \times 10^{-6})(8.00^2)(3.00^2)$

$= 1.44 \times 10^{-3}$ J

1 for correct maximum kinetic energy B1

1 for correct shape (2 periods with peak slightly to the left of origin) B1

(b) An oscillator with damping can vibrate at resonance with amplitude that remains constant with time. M1

This is because the energy supplied by driver is equal to energy lost due to dissipative forces. A1

6 **(a)** When a p.d. of 240 V is applied across it, then the power dissipated by the lamp is 100 W. B1

(b) Resistance of lamp $R = \frac{V^2}{P} = \frac{240^2}{100} = 576\ \Omega$

Current flowing through the filament ,

$$I = \frac{V}{R} = \frac{280}{576} = 0.486\text{ A}$$

In one second, quantity of charge flowing through it, Q = 0.500 C C1

$\frac{n}{t} = \frac{Q}{e} = \frac{0.486}{1.6\times10^{-19}} = 3.04\times10^{18}\ \text{s}^{-1}$

A1

(c) The temperature (or internal energy) of the filament rises with work done by the electrons on the filament. B1

This causes more vigorous lattice vibration of the atoms resulting in greater collision frequency between electrons and atoms, causing the resistance to rise. B1

To include explanation that just involve collisions of electrons with lattice ions.

7 **(a)**

$$A = A_0 e^{-\lambda t}$$

$$3.7 \times 10^{11} = A_0\, e^{-\frac{\ln 2}{5.2}(2.5)}$$ M1

$$A_0 = 5.16 \times 10^{11}$$ A1

(b)

$$A_0 = \lambda N_0$$

$$N_0 = \frac{5.16 \times 10^{11}}{5.2 \times 365 \times 24 \times 60 \times 60} \quad \text{C1}$$

$$= 1.2216 \times 10^{20} \quad \text{C1}$$

mass = $\frac{1.2216 \times 10^{20}}{6.02 \times 10^{23}} \times 60 = 0.012\, g$ A1

(c) Rate of emission of energy B1

= $(3.7 \times 10^{11} \times (0.31 + 1.17 + 1.33)(1.60 \times 10^{-19})$

= 0.166 W B1

8 **(a)** **(i)** potential divider method gives C1

$V = 9.0\left(\frac{470}{470+1650}\right)$

$V = 2.00$ V A1

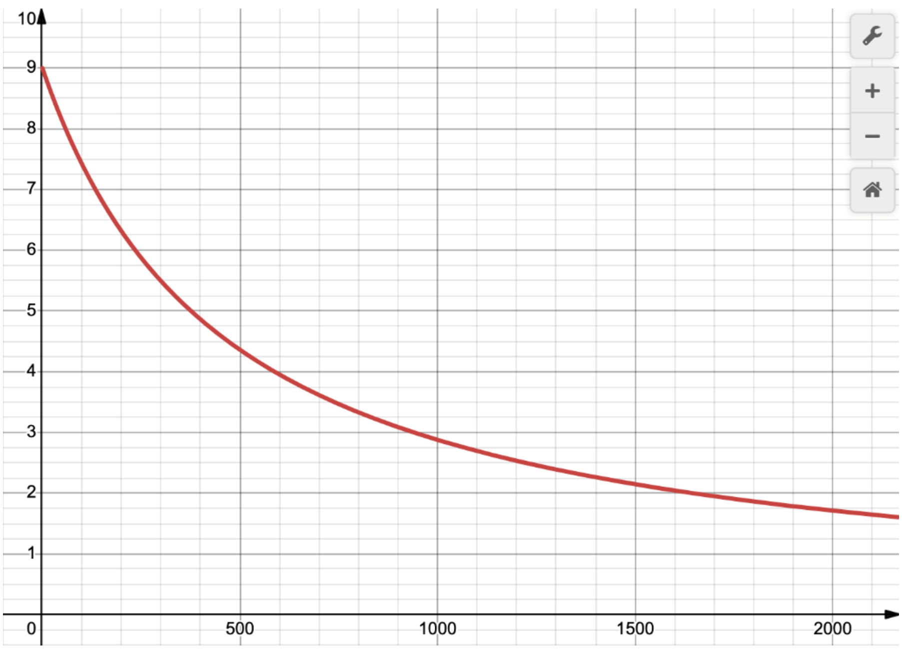
(ii) downward sloping with decreasing gradient B1

cuts at (0,9) B1

and graph below 2 V (or the value in (a)(i)) when curve reaches $R_1 = 2000\ \Omega$

Example

voltmeter reading / V



R_1 /Ω

Justification

$V = 9\left(\frac{470}{470+R}\right)$

(b) **(i)** $\frac{1}{R_{\parallel}} = \frac{1}{470} + \frac{1}{100\ 000}$, $R_{\parallel} = 467.8\ \Omega$ B1

$V = 9\left(\frac{467.8}{467.9+1650}\right) = 1.988$ B1

$\frac{1.988-1.955}{1.955} \times 100\% = -0.35\%$ A1

(ii) No significant changes / very slight differences / voltmeter may not have enough precision to detect the difference. B1

comparison using numbers. B1

E.g.

internal resistance is 3 orders of magnitude smaller than resistance in circuit.

Or, take internal resistance to be maximum at 10 Ω, fraction $\approx \frac{10}{1645+640} = 0.004$.

internal resistance is small compared to resistance in circuit (1 mark maximum)

9 **(a)** **(i)** The electric field strength at a point is defined as the electric force per unit positive charge placed at that point: B1

(ii) Electron gains speed as it moves from point A of 200V to 300V. B2 for all 3

Its speed remains approximately constant when it is between the region of 300V.

Its speed decreases (to the same initial speed) as it moves from 300V to point B

(iii) Loss in kinetic energy = gain in electric potential energy

$= q\,(V_C - V_A)$

$= (-1.60 \times 10^{-19})\,(0 - 200)$ C1

$= 3.20 \times 10^{-17}$ J A1

To deduct one mark if answer does not reflect negative value which represents the loss in KE.

(iv) Distance between 300V and 100V beside B is 2.7×10^{-2} m

Magnitude of field strength

$= |\Delta V/\Delta x|$

$= (300 - 100)/(2.7\times10^{-2})$ C1

$= 7400$ V m^{-1} (7100 – 7700) A1

(v) Vertically downwards B1

(vi) $F = qE$

$=(1.60\times10^{-19})(7400)$

$=1.18\times10^{-15}$ N A1

Vertically upwards. A1

(b) **(i)** The gravitational force acting on the object provides the centripetal force.

$\frac{GMm}{R^2} = mR\omega^2$ B1

$$\omega = \sqrt{\frac{GM}{R^3}}$$

(ii) A longer arrow acts towards the Sun. B1
A shorter arrow acts towards the Earth

(iii) The centripetal force acting on the SOHO depends on both the gravitational forces due to the Sun and the Earth. Hence, the expression in (i) does not apply to the angular velocity for SOHO. B1

Due to the gravitational force acting on SOHO by the Earth, the net centripetal force acting on SOHO is lower. This will result in a lower angular velocity for SOHO that can be comparable to that of the Earth at a further distance from the Sun. B1

(iv) $$\frac{GMm}{R^2} - \frac{GM_{Earth}m}{R_{Earth}{}^2} = mR(\frac{2\pi}{T})^2$$

$$\frac{GM}{R^2} - \frac{GM_{Earth}}{R_{Earth}{}^2} = R(\frac{2\pi}{T})^2$$

where m is the mass of SOHO, M_{Earth} is the mass of the Earth and R_{Earth} is the distance from SOHO to the Earth. From the above equation, the orbital period does not depend on the mass of SOHO B1

(c) (i) Since $\frac{GM_E}{R_E{}^2} = 9.81$, $R_E = \sqrt{\frac{G(6.0 \text{ x } 10^{24})}{9.81}} = 6.39 \text{ x } 10^6$ m C1

$$v = \sqrt{\frac{G(6.0 \text{ x } 10^{24})}{(7.0+6.39) \text{ x } 10^6}} = 5470 \text{ m s}^{-1}$$ A1

(ii) GPE at infinity + KE at infinity
= GPE of stone on satellite + KE of stone on satellite

$$0 + 0 = -\frac{G(6.0 \text{ x } 10^{24})m}{(7.0+6.39) \text{ x } 10^6} + \frac{mv^2}{2}$$

v = 7731 m s^{-1} C1

Minimum projection speed = 7731 + 5470 = 1.3 x 10^4 m s^{-1} A1

(iii) The lowest speed of projection will be 7731 – 5470 = 2261 m s^{-1} relative to the speed of satellite and the stone should be projected in the same direction as the movement of satellite. Any other direction of projections will not lead to lower speed to escape from the Earth's gravitational field. B1

10	**(a)**	**(i)**	Magnetic force provides centripetal force.	M1
			$Bqv = mr\omega^2 = mr\left(\frac{2\pi}{T}\right)^2$	A1
			$T = \frac{2\pi m}{qB}$	
		(ii)	Into the page/plane	B1
		(iii)	$f = \frac{qB}{2\pi m} = \frac{(2 \times 1.60 \times 10^{-19})(0.850)}{2\pi(6.88 \times 10^{-27})}$	M1
			$= 6.29 \times 10^6$ Hz	A1
		(iv)	Gain in KE per revolution	
			$= 2 \times 450 \times 2 \times 1.60 \times 10^{-19}$	M1
			$= 2.88 \times 10^{-16}$ J	A1
		(v)	Gain in KE = ½ mv^2	
			$3 \times 2.88 \times 10^{-16} = \frac{1}{2}(6.88 \times 10^{-27})(v^2)$	M1
			$v = 501000$ m s^{-1}	A1
		(vi)	• Same time intervals when travelling with constant speed	B1
			• (Shorter and shorter time intervals when accelerating)	
			• Smaller increase in speed each acceleration	B1
		(vii)	• The cyclotron uses the same accelerating gap, which enables it to become compact and therefore saves cost in many ways.	B1
			• The accelerating particles can be taken to higher energy states within the small space available.	
			• Besides the small size of a cyclotron, there are other factors which reduce the cost of this device. For example the cost of the building which contains it, the cost of the foundation and the cost of radiation shielding.	
			• Another big advantage of a cyclotron is that it has only one electric driver. This makes it cost-efficient because of less cost equipment and less costly power.	
			• Cyclotrons can produce the particle beam in a continuous form.	
	(b)	**(i)**	$E = -Blv = -(0.080)(1.5)(3.00)$	
			$= 0.36T$	M1
			$I = \frac{E}{R}$	
			$= \frac{0.36}{4.0} = 0.090A$	A1
		(ii)	*b*. Induced e.m.f. flows from lower to higher potential.	B1
		(iii)	When the rod is moving at constant speed, due to the cutting of magnetic flux, there will be an <u>induced current through it.</u> The direction of the induced current will be such that there will be a	B1
			<u>magnetic force to oppose the motion causing it.</u>	B1
			Therefore, to keep the rod moving at constant speed, a force needs to be applied	

(iv) Work done by external force = Electrical energy supplied to keep charges moving / heat dissipated by current in the resistor R / joule heating in resistor R — B1

(v) $F = BIL$
$= 0.080\ (1.5)(0.090)$ — M1
$= 0.0108$ N — A1