RVHS JC2 H2 Physics Prelims Paper 2 Mark Scheme

1	**(a)**		From the measured width of the cubes, take average. Compare the average value to the expected value of 2.0 cm; the closer it is to 2.0 cm, the more accurate is the dimension of the cubes. If the average width is between 1.95 cm and 2.04 cm, it can be considered to be accurate.	B1 B1
	(b)		From the measured width of the cubes, compare the widths of each cube to one another. The closer the widths of each cube, the more precise is the dimensions of his printed cubes.	M1 A1
2	**(a)**		The Principle of Conservation of Linear Momentum states that the total momentum of a system remains constant provided no external resultant force acts on the system.	B1 B1
	(b)		An elastic collision between two or more objects is one in which kinetic energy is conserved.	B1
	(c)		initial momentum = (0.400)(5.0) = 2.0 kg m s^{-1} momentum of P after collision = (0.400)(–0.40) = –0.16 kg m s^{-1} momentum of Q after collision = 2.0 – (–0.16) = 2.16 kg m s^{-1}	M1 A1
	(d)		For elastic collision, relative speed of approach = relative speed of separation $u_P - u_Q = v_Q - v_P$ $5.0 - 0 = v_Q - (-0.40)$ $v_Q = 4.6$ m s^{-1} $m_Q v_Q = 2.16$ kg m s^{-1} $m_Q = (2.16) / (4.6) = 0.47$ kg	M1 A1
	(e)		$F = \Delta p / \Delta t$ $= (2.16 - 0) / (0.060)$ = 36 N	A1
3	**(a)**	**(i)**	The positive direction was defined to be the direction from A to B. $\text{gravitational field strength} = -\frac{GM_A}{r^2} + \frac{GM_B}{r^2}$ $= \frac{6.67\times10^{-11}}{(0.5\times3.85\times10^8)^2}\left(-5.07\times10^{24} + 3.23\times10^{24}\right)$ $= -3.31\times10^{-3}\ N\ kg^{-1}$ Accept 3.31 x10^{-3} N kg^{-1}	M1 A1

(ii)

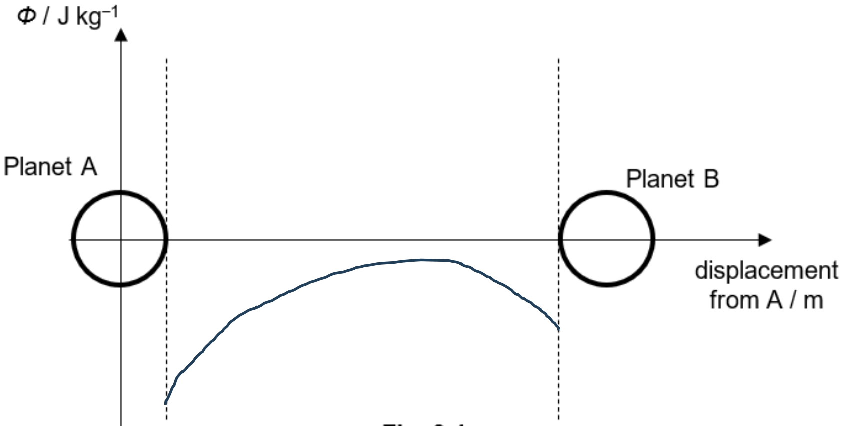

Fig. 3.1

General shape correct.
Gravitational potential at surface of A is lower than that at B

B1

Marker's comments:

- Many students left a gap between the line to the dotted lines (the surface of both planets). This is not acceptable since the instruction stated specifically to draw from the surface of one planet to the other. Marks cannot be awarded for incomplete diagrams.
- Some students drew the curve as if the dotted lines are the asymptotes. This is incorrect, since it suggests that the magnitude of the gravitational potential at the surface of the planet approaches infinity.
  Incorrect example:

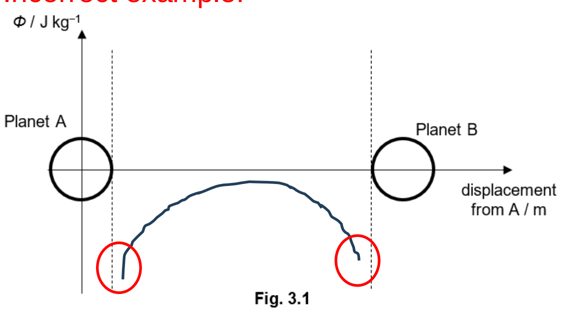

Fig. 3.1

(iii)

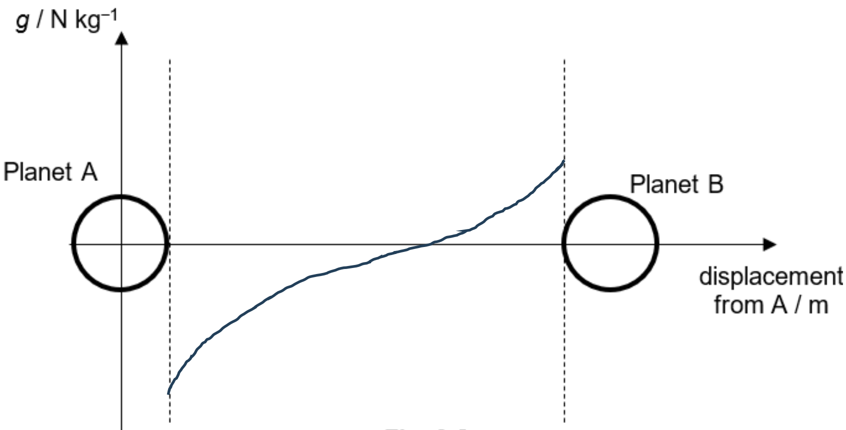

Fig. 3.2

General shape

B1

B1

			Magnitude of *g* at surface of A larger than that at B and neutral point closer to planet B Marker's comments: • Similar to previous question, some students drew the curve as if the dotted lines are the asymptotes. This is incorrect, since it suggests that the magnitude of the gravitational field strength at the surface of the planet approaches infinity.	
	(b)	**(i)**	• By Newton's 3rd law of motion, Force on C by D = force on D by C • The same magnitude of force provides for the centripetal force on each star about P. • The **angular velocity *ω* is the same** for both stars. Hence, $M_C r_C \omega^2 = M_D r_D \omega^2$ $\frac{M_D}{M_C} = \frac{r_C}{r_D}$ $\therefore \frac{r_C}{r_D} = \frac{1}{2}$	M1
		(ii)	Since $\frac{r_C}{r_D} = \frac{1}{2}$ and $\frac{M_C}{M_D} = 2$, $gravitational\ force = \frac{GM_C \frac{M_C}{2}}{(r_C + 2r_C)^2} = \frac{GM_C{}^2}{18r_C{}^2}$	M1
		(iii)	Gravitational force on C by D provides for centripetal force on C $\frac{GM_C{}^2}{18r_C{}^2} = M_C r_C \omega^2$ $M_C = \frac{18r_C{}^3}{G}\left(\frac{2\pi}{T}\right)^2$ $= \frac{18(2.40 \times 10^{12})^3}{6.67 \times 10^{-11}}\left(\frac{2\pi}{3.84 \times 10^9}\right)^2$ $= 9.99 \times 10^{30}\ kg$	M1 M1 A1
4	**(a)**	**(i)**	$v = f\lambda$ $0.90 = f(0.30)$ $f = 3.0$ Hz	M1
		(ii)	$f = \frac{1}{2\pi}\sqrt{\frac{28}{m}}$ m = 0.0788 kg	A1
		(iii)	**1.** <u>**Driving force is larger**</u> due to the larger amplitude of wave, OR more energy transfer.	M1

				Amplitude of the vertical oscillations will also increase.	A1
			2.	Wavelength of wave increases. Since the speed remains the same, by $v = f\lambda$, driving frequency of wave will decrease. Since driving frequency is not equal to natural frequency, **<u>amplitude will decrease</u>** (no more resonance)	M1 A1
			3.	Damping force increases. Therefore, amplitude decreases.	M1 A1
	(b)	**(i)**	Light in which the oscillations of the electromagnetic fields <u>are all in a single plane.</u>		A1
		(ii)	The displacements due to the two waves are in perpendicular axes, thus their <u>vector sum will not be able to produce</u> distinct maxima and <u>minima</u>, since they can <u>never be</u> in the same or <u>in opposite directions</u> (OR there will not be complete cancellation). Hence, the contrast between bright and dark fringes is not observable.		M1 A1
		(iii)	For *X*, after the initial unpolarised light passed through the polariser, the light became plane polarised with $I_X = \frac{1}{2}I$ with amplitude $A_X = A$ (i.e. unchanged for any θ value of *X*). Hence, $I_Z = I_X(\cos^2 45°)(\cos^2 45°)$ $= \frac{I}{2}\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)$ $= \frac{I}{8}$		M1 M1 A1
5	**(a)**	**(i)**	Correct directions with line of action of force vector passing through charges. (Arrow for negative charge pointing to the left and positive charge to the right)		A1
		(ii)	$F = qE$ $= \left(1.2\times10^{-15}\right)\left(2.0\times10^{3}\right)$		
			$= 2.4\times10^{-12}$ N		A1
		(iii)	$\tau = Fd\sin\theta$		
			$= \left(2.4\times10^{-12}\right)\left(2.5\times10^{-3}\right)\sin 35^{\circ}$		M1
			$= 3.4(4)\times10^{-15}$ N m		A1
		(iv)	either rotates to align with the field or oscillates (about a position) clockwise / with the positive charge on the right of the centre of dust particle		B1

	(b)	**(i)**	electric force is **negative of potential energy gradient**	B1
		(ii)	The two charges have opposite signs since the force between the charges is attractive / negative.	B1
		(iii)	gradient = $= \dfrac{-1.00-(-3.00)}{(9.6\times10^{-10}-4.4\times10^{-10})}$ $= 3.846\times10^{9}$	M1
			$F = 3.846\times10^{9}\times1.6\times10^{-19}$	C1
			$= 6.2\times10^{-10}N$	A1
6	**(a)**		Let J be the contact point between the jockey and the wire XY $R_{XJ} = \dfrac{L_{XJ}}{L_{XY}}R_{XY} = \dfrac{0.48}{1.2}(20.0) = 8.0\,\Omega$ $V_{XJ} = \dfrac{R_{XJ}}{R_{XY}}(4.0) = \dfrac{8.0}{23.0}(4.0) = 1.3913V$ By considering the secondary circuit, p.d. across resistor R = 1.3913 V p.d. across 1.0 Ω resistor = 0.50 V By principle of potential divider, $\dfrac{R_{1\Omega}}{R_{resistor\ R}} = \dfrac{V_{1\Omega}}{V_{resistor\ R}}$ $R_{resistor\ R} = \dfrac{1.3913}{0.50}(1.0) = 2.8\,\Omega$	C1 C1 A1
	(b)	**(i)**	I = nAvq v = I / nAq = 2.8 / ($(8.49\times10^{28})(0.20\times10^{-6})(1.6\times10^{-19})$ = 1.03×10^{-3} m s^{-1}	M1 A1
		(ii)	$R = \dfrac{V}{I} = \dfrac{0.72}{2.8}$ $R = \dfrac{\rho l}{A}$ $\rho = \dfrac{RA}{l} = \dfrac{\left(\dfrac{0.72}{2.8}\right)(0.20\times10^{-6})}{3.0} = 1.7\times10^{-8}\ \Omega$m	C1 A1
		(iii)	As the current increases, the temperature increases since the <u>rate at which electrons collide into the metal lattice increases</u>. As temperature increases, <u>lattice ions vibrate more vigorously, hindering the flow of electrons</u>. Hence, its resistance increases.	B1 B1
7	**(a)**		A discrete unit/quantum/packet of electromagnetic radiation energy.	A1
	(b)		An emission line spectra is due to emission of photons during transition between energy levels. Since spectrum consists of discrete lines [rather than a continuous spectrum], the energy levels must be discrete.	B1 B1

	(c)		Excited level = –13.6 + 13.2 = –0.4 eV, nearest level is 5 Highest frequency transition from 5 to 1. Energy = hf = –0.54 –(–13.6) ev = 13.06 eV f = 3.15 x 10^{15} Hz	M1 M1 A1
	(d)	**(i)**	Negative potential difference will prevent the most energetic electrons from reaching the collector plate.	B1
		(ii)	photon energy = work function + KE of electrons (3.4–0.54) x 1.6 x10^{-19} = work function + 0.72 x 1.6 x 10^{-19} Work function = 3.42 x 10^{-19} J	 M1 A1
		(iii)	No of electrons per sec = 0.21 × 10^{-6} /1.6 × 10^{-19} No of photons per sec = 10^5 × no of electrons per sec = 1.31 × 10^{17} s^{-1}	 M1
8	**(a)**	**(i)**	During braking, when the coil attached to the wheel turns in the magnetic field, the magnetic flux linkage through the coil will be changing.	M1
			According to Faraday's law, since there is a change in magnetic flux linkage in the coil, there will be an induced e.m.f.	M1
			This will produce a current/electricity which can then be stored in the battery and used to power the engine thus improving efficiency.	A1
		(ii)	At lower speeds, the rate of change of magnetic flux linkage will be less,	M1
			hence less induced e.m.f. and less efficiency	A1
		(iii)	Magnetic flux is the product of area and the component of magnetic flux density perpendicular to that area.	B1
		(iv)	$N\Phi = NBA\cos\theta$	M1
		(v)	$\theta = \omega t$	C1
			$E = -\dfrac{dN\Phi}{dt} = -\dfrac{dNBA\cos\omega t}{dt} = -\omega NBA\sin\omega t$	M1
			max $E = \omega NBA = (30 \times 2\pi)(75 \times 0.70 \times 200 \times 10^{-4})$	M1
			$=$ 200 V (198)	A1
		(vi)	Period doubles and	B1
			height halves	B1
	(b)		Less wear and tear for friction brake pads Or smoother braking / prolonged battery life	B1

	(c)		Heavier vehicles have more mass / inertia, thus their drivers tend to use brakes more often to control the speed of the car hence recovering more energy. OR The regenerative braking system is used in parallel to friction braking system. Heavier vehicles have more momentum/KE/inertia hence require more force to stop. Hence regenerative braking can recover more energy as friction braking might not be able to stop the vehicle completely in that time, as opposed to a lighter vehicle.	B1