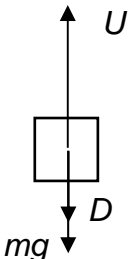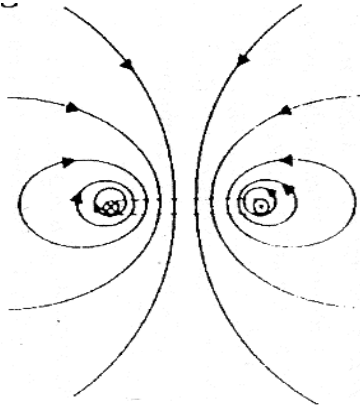## Answers to JC2 Preliminary Examination Paper 2 (H1 Physics)
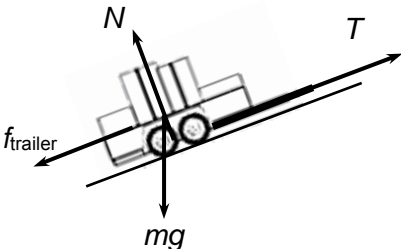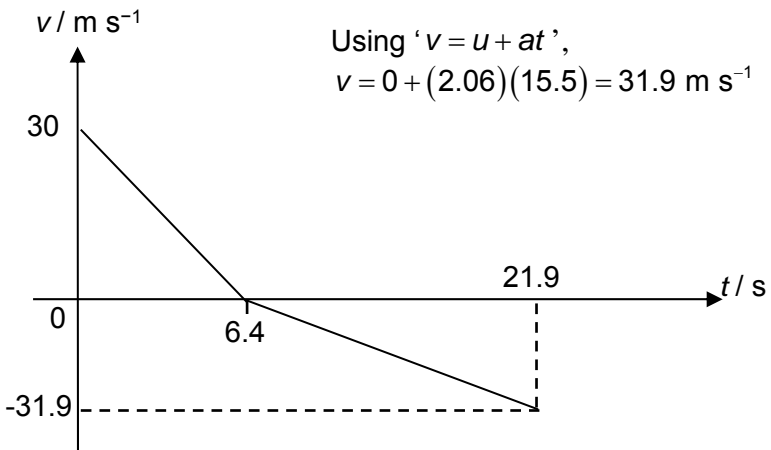
Suggested Solutions:

No.	Solution	Remarks
1(a)	Systematic errors result in all readings taken being faulty in one direction, such that all the readings are either above or below the true value.	[1]
	Random errors result in a scatter of readings about a mean value, such that the readings have an equal chance of being above or below the true value.	[1]
1(b)	value of W, $W = \dfrac{(1 \times 10^6)(2.03 \times 10^{-3})^4 (20 \times 10^3)}{160 \times 10^{-3}} = 2.122$	[1] for W
	$\dfrac{\Delta W}{W} = 4(\dfrac{\Delta r}{r}) + (\dfrac{\Delta p_1 + \Delta p_2}{p_1 - p_2}) + \dfrac{\Delta h}{h}$ $\dfrac{\Delta W}{W} = 4(\dfrac{0.03}{2.03}) + (\dfrac{4}{20}) + \dfrac{8}{160} = 0.309$	[1] for fractional uncertainty [1] for correct answer
	therefore $W = (2.1 \pm 0.7)$ Pa m^3	
2(a)	The work done by a constant force on a particle is defined as the <u>product of the magnitude of the force</u> and the <u>displacement in the direction of the force</u>.	[1] [1]
2 (b)(i)	work done on object $= U \times$ displacement $= (0.50)(0.10)$ $= 0.050$ J	[1] for correct value
2(b)(ii)	By conservation of energy, Gain in GPE + Gain in KE = Work done by water on object $(mgh - 0) + (\dfrac{1}{2}mv^2 - 0) = 0.050$ $(0.040)(9.81)(0.10) + \dfrac{1}{2}(0.040)v^2 = 0.050$ $v^2 = 0.538$ $v = 0.73$ m s^{-1}	[1] for correct substitution [1] for correct value
2(b)(iii)	In practice, the object loses energy as it floats up, since it is doing work against drag forces. This means that the gain in kinetic energy is smaller, since the gain in gravitational potential energy and the work done by the water on the object remains the same.	[1]
	Hence, the value of v in practice is smaller than that in **(b)(ii)**.	[1]

2(c)(i)		[1] for drawing all 3 force vectors [1] for correct lengths of vectors (*D* and *mg* shorter than *U*, but *D* need not be shorter than *mg*)
2(c)(ii)	$D = U - mg$ $\quad = 0.50 - 0.040 \times 9.81$ $\quad = 0.11 \text{ N}$	[1]
2(c)(iii)	Since the object is moving at constant velocity, there is no net force acting on the object. Thus the object is in translational equilibrium.	[1] [1]
3(a)(i)	<u>As p.d. increases, the ratio of p.d. to current increases.</u> This shows that resistance increases as p.d. increases.	[1] or any logical answer
3(a)(ii)	As p.d. across the lamp increases, power dissipation as heat increases, increasing the temperature of the filament. This leads to an increase in amplitude of vibration of lattice ions. This causes electrons to collide more frequently with the lattice ions. Hence R increases.	[1] [1]
3(b)(i)	In the day, the resistance of the LDR is 10 Ω. As the lamp is connected in parallel with the LDR, the <u>effective resistance of two resistors connected in parallel will always be lower than the lower resistance of the two resistors</u>. Hence, the <u>effective resistance will always be less than 10 Ω</u>. As this set of resistors is connected in series with a fixed resistor of 20 Ω, <u>by potential divider principle, the p.d. across will always be less than 6 V</u>, hence unable to attain normal working condition.	[1] [1]
3(b)(ii)	For p.d. across lamp has to be 6 V for normal working conditions. Thus, by potential divider principle, effective resistance of lamp and LDR, $R_{\text{effective}} = 20$ Ω. $\dfrac{1}{R_{\text{effective}}} = \dfrac{1}{R_{LDR}} + \dfrac{1}{24}$ $\dfrac{1}{20} = \dfrac{1}{R_{LDR}} + \dfrac{1}{24}$ $R_{LDR} = 120$ Ω	[1] [1]

4(a)		[1] correct shape and magnitude [1] correct direction
4(b)(i)	$B_c = \dfrac{(4\pi \times 10^{-7})(60)(0.100)}{2(0.070)} = 5.39 \times 10^{-5}\,\text{T}$ Towards the East.	[1] correct magnitude [1] correct direction
4(b)(ii)	$B_R = \sqrt{(53.9)^2 + (50)^2} \times 10^{-6}$ $B_R = 7.35 \times 10^{-5}\,\text{T}$ $\tan\theta = \dfrac{53.9}{50}$ $\theta = 47.1°$ East of North	[1] correct magnitude [1] correct direction
5(a)	Rhea: $\lg T = \lg(0.389 \times 10^6) = 5.59$ $\lg r = \lg(0.527 \times 10^9) = 8.72$ Titan: $\lg T = \lg(1.38 \times 10^6) = 6.14$ $\lg r = \lg(1.22 \times 10^9) = 9.09$	[1] for correct values for $\lg T$ [1] for correct values for $\lg r$

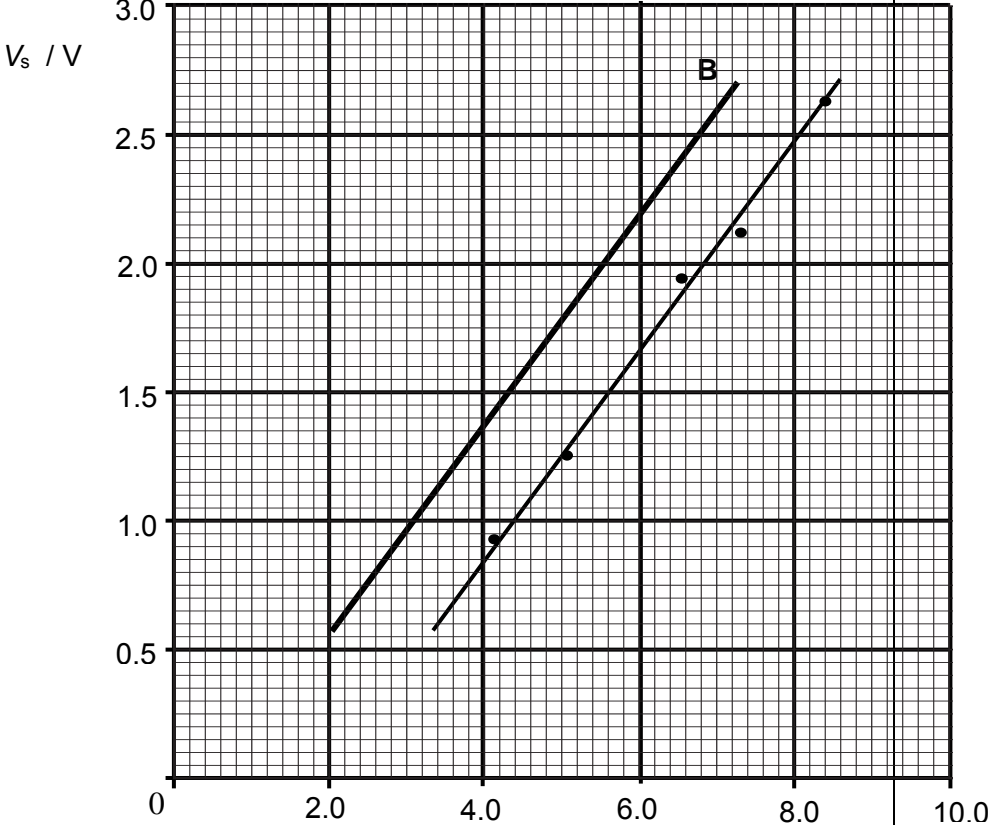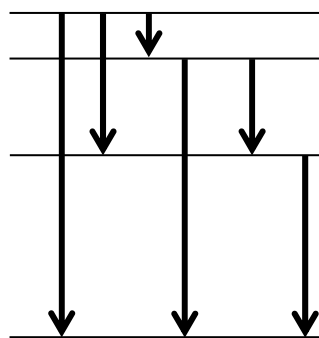| 5(b)		[1] for correct plot of both points
	lg (*T* / s) 	[1] for good line of best fit
5(c)	gradient $= \dfrac{6.60 - 5.11}{9.40 - 8.40}$ $= \dfrac{1.49}{1.00}$ $= 1.49$	[1] for correct substitution [1] for correct value approximate to 1.5
5(d)(i)	From Fig. 5.2, $\lg T = 0.5\lg\dfrac{4\pi^2}{GM} + 1.49\lg r$ Substituting (9.40, 6.60)	[1] for correct equations and substitution [1] for correct answer (Note: mass of Saturn $= 5.68 \times 10^{26}$ kg

	$0.5 \lg \dfrac{4\pi^2}{GM} = 6.60 - 1.49 \times 9.40$ $\qquad\qquad = -7.406$ $\lg \dfrac{4\pi^2}{GM} = -14.812$ $\dfrac{4\pi^2}{GM} = 10^{-14.812}$ $\qquad = 1.542 \times 10^{-15}$ $M = \dfrac{4\pi^2}{(6.67 \times 10^{-11})(3.664 \times 10^{-15})}$ $\qquad = 3.84 \times 10^{26}$ kg	
5(d)(ii)	Multiple sets of readings were used in calculating the mass in (d)(i), as compared to only one set used in the student's calculation. Using multiple sets of readings help to reduce the random error through the use of a best fit line. This means that the student's calculation will be less accurate than the values calculated in (d)(i).	[1] [1]
6(a)	The rate of change of momentum of a body is proportional to the resultant force that acts on it and has the same direction as the resultant force.	[1] correct statement
6(b)	Let the force delivered by the car's engine be F_{car}. For the car, $F_{car} - f_{car} - T = (2000)a$ For the trailer, $T - f_{trailer} = (1000)a$ When the force in tow bar is maximum, $20000 - 1300 = (1000)a \Rightarrow a = 18.7$ m s^{-2} $F_{car} - f_{car} - T = (2000)a$ $\Rightarrow F_{car} = f_{car} + T + (2000)a$ $\qquad = 2600 + 20000 + (2000)(18.7) = 60000$ N	[1] for correct equations [1] for correct a [1] for correct answer
6(c)(i)	 T : tension in tow bar $\qquad\qquad$ mg : weight of trailer N : normal reaction $f_{trailer}$: resistive force acting on trailer	[1] for forces labelled correctly

6(c)(ii)	$T - f_{trailer} - mg\sin 20° = (1000)a$	[1] for correct equation
	$\Rightarrow T - 1300 - (1000)g\sin 20° = (1000)3$	
	$\Rightarrow T = 7700$ N	[1] for correct answer
6(c)(iii) 1.	As the trailer continues to move upwards, friction is down the slope.	
	$f_{trailer} + mg\sin 20° = (1000)a$	[1] for correct equation
	$\Rightarrow 1300 + (1000)g\sin 20° = (1000)a$	
	$\Rightarrow a = 4.66$ m s^{-2}	[1] for correct answer
6(c)(iii) 2.	Velocity of the trailer at the instant the tow bar broke is v.	
	Using '$v^2 = u^2 + 2as$',	
	$v^2 = 0 + 2(3)(150) \Rightarrow v = 30$ m s^{-1}	[1] for correct v
	Time taken for it to come to rest is t.	
	Using '$v = u + at$',	[1] for correct t
	$0 = 30 + (-4.66)t \Rightarrow t = 6.4$ s	
6(c)(iii) 3.	Using '$s = ut + \frac{1}{2}at^2$', distance travelled up the slope is	[1] for correct distance up the slope
	$s = (30)(6.4) + \frac{1}{2}(-4.66)(6.4)^2 = 96.6$ m	
	When the trailer is on the way down the slope,	
	$mg\sin 20° - f_{trailer} = (1000)a$	
	$\Rightarrow mg\sin 20° - 1300 = (1000)a$	
	$\Rightarrow a = 2.06$ m s^{-2}	[1] for correct a
	Using '$s = ut + \frac{1}{2}at^2$',	
	$150 + 96.6 = 0 + \frac{1}{2}(2.06)t^2 \Rightarrow t = 15.5$ s	
	Total time taken to return to the bottom of the slope = 6.4 + 15.5 = 21.9 s	[1] for correct t till bottom of slope
6(c)(iv)	Using '$v = u + at$', $v = 0 + (2.06)(15.5) = 31.9$ m s^{-1}	[1] for correct slopes [1] for correct time labels [1] for correct velocity labels

6(c)(v)	From Newton's 2nd Law, $F = \dfrac{\Delta p}{\Delta t}$ $= \dfrac{(1000)(15) - 0}{0.1}$ $= 1.5 \times 10^5$ N	[1] for application of Newton's 2nd Law [1] for correct Δp [1] for correct force
7(a)	The principle of superposition states that when two or more travelling waves of the same type meet at a point in space, the resultant displacement at that point is the vector sum of the displacements due to each of the waves at that point.	[2]
7(b)(i)	They are coherent as there is a constant phase difference between the two waves.	[2] for stating coherent with reason
7(b)(ii)	The two waves meet in antiphase at point X and thus destructive interference takes place and hence a minimum intensity is obtained. As the amplitude of the two waves are not equal, incomplete cancellation will take place at point X and hence, the resultant intensity is non-zero.	[1] [1]
7(b)(iii)	$f = \dfrac{1}{T} = \dfrac{1}{0.8 \times 10^{-3}} = 1250$ Hz $\lambda = \dfrac{v}{f} = \dfrac{330}{1250} = 0.264$ m	[1] for correct f [1] for correct λ
7(b)(iv)1.	$x = \dfrac{\lambda D}{a} = \dfrac{(0.264)D}{0.20}$ Distance OX$= \dfrac{1}{2}x = \left(\dfrac{1}{2}\right)\dfrac{(0.264)D}{0.20}$ $2.4 = \left(\dfrac{1}{2}\right)\dfrac{(0.264)D}{0.20}$ $D = 3.64$ m	[1] for correct expression [1] for recognizing that OX = 0.5x [1] for correct answer
7(b)(iv)2.	The distance D is much greater than the distance between the loudspeakers	[1]
7(b)(v)	Let the amplitude of wave from P be A. $I = kA^2$ Thus, amplitude from Q will be 2A. At point O, waves meet in phase. Resultant amplitude = 2A + A = 3A $I = kA^2$ $I = k(3A)^2 = 9kA^2 = 9I$	[1] for resultant amplitude [1] for $I = kA^2$ [1] for answer

7(c)(i)	Zero intensity.	[1]
7(c)(ii)1.	The angle between the polarisation axes of successive polaroids is not 90°.	[1]
7(c)(ii)2.	$A_R = A\cos\theta$ $A_Q = A_R\cos(90° - \theta)$ $= A\cos\theta\cos(90° - \theta)$ $= A\cos\theta\sin\theta$ $A_Q = \dfrac{1}{2}A$ $A\cos\theta\sin\theta = \dfrac{1}{2}A$ $\cos\theta\sin\theta = \dfrac{1}{2}$ $2\cos\theta\sin\theta = 1$ $\sin 2\theta = 1$ $\theta = 45°$	[1] for A_R [1] for A_Q [1] for answer
8(a)	Photoelectric effect is the <u>emission of electrons from a metal surface</u> when it is exposed to <u>electromagnetic radiation of sufficiently high frequency or frequency greater than the threshold frequency</u>.	[1] for emission of electrons [1] for frequency greater than threshold or sufficiently high frequency
8(b)(i)	From Einstein's photoelectric formula, $V_s = \dfrac{h}{e}f - \dfrac{h}{e}f_0$ where $\dfrac{h}{e}$ is the gradient of Fig. 8.1. Thus, Planck constant, $h = (\text{gradient})e$ From the graph, $\text{gradient} = \dfrac{2.5 - 0.85}{(8 - 4)\times 10^{14}}$ Thus, $h = (\text{gradient})e = \dfrac{2.5 - 0.85}{(8 - 4)\times 10^{14}}e = 6.6\times 10^{-34}$ J s	[1] for gradient [1] for correct h
8(b)(ii)	Work function energy, $\Phi = hf_0 = (6.63\times 10^{-34})(1.9\times 10^{14}) = 1.3\times 10^{-19}$ J f_0 is given by the x-axis intercept of Fig. 8.1.	[1] for f_0 from graph [1] for correct Φ
8(b)(iii)	The data point with the greatest stopping potential will give the maximum K.E. From Fig. 8.2, the maximum stopping potential is 2.65 V. This will give the maximum K. E.. Since $\dfrac{1}{2}mv_{max}^2 = eV_s \Rightarrow p = mv_{max} = \sqrt{2meV_s}$ Applying deBroglie hypothesis, $p = \dfrac{h}{\lambda} \Rightarrow \lambda = \dfrac{h}{p} = \dfrac{h}{mv_{max}} = \dfrac{h}{\sqrt{2eV_s m}} = 7.54\times 10^{-10}$ m	[1] for largest stopping potential measured [1] for momentum [1] for correct answer

8(c)	Not affected as changing intensity but keeping frequency or wavelength constant, resulted in the number of photons emitted per second to be higher but each photon still have the same amount of energy.	[1] for correct answer: No [1] for correct explanation
8(d)	**Fig. 8.1** [1] B is parallel to the first graph. [1] x-axis intercept of B must be positive.	
8(e)(i)	If all the electron's energy is absorbed, the electron could reach −5.17 + 3.7 = −1.47 eV level. Since there are no such energy level, the electron can only excite to −1.56 eV or $n = 4$ level.	[2] deduct 1 mark for each error

Fig. 8.1 axis labels: V_s / V (vertical), f / 10^{14} Hz (horizontal)

8(e)(ii)	For transition to $n = 4$ level, energy required = $-1.56 - (-5.17) = 3.61$ eV Thus, energy remaining as K.E. = $3.70 - 3.61 = 0.09$ eV For transition to $n = 2$ level, energy required = $-3.07 - (-5.17) = 2.10$ eV Thus, energy remaining as K.E. = $3.70 - 2.10 = 1.60$ eV Thus, range of K.E. remaining is between 0.09 eV and 1.60 eV.	[1] for minimum K.E. [1] for maximum K.E.
8(e)(iii)	 $n = 4$ to $n = 3$ $n = 3$ to $n = 2$ $n = 4$ to $n = 2$ $n = 2$ to $n = 1$ $n = 3$ to $n = 1$ $n = 4$ to $n = 1$ increasing frequency	[1] 1 mark for appropriate spacing between lines [1] 1 mark of correct sequence of lines
8(f)	If the electron absorbed the incoming photon, there is no energy levels for it to excite to. As such, there will be no transition observed.	[1] for no lines observed