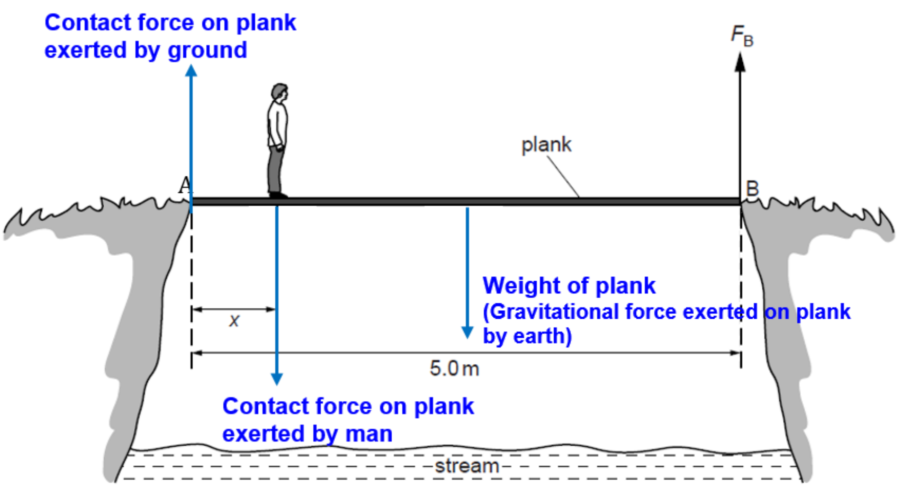
2020 JC2 H1 Physics Preliminary Examination Paper 2 Suggested Solutions (SECTION A)

1	**(a)**	**(i)**	 • **(Contact)** **<u>force on plank by ground</u>** – correct direction and labelling • **(Contact)** **<u>force on plank by man</u>** – correct direction and labelling • **<u>Weight of plank (force on plank by Earth)</u>** – correct direction and labelling **Do not accept symbols.*	**B1** **B1** **B1**
		Marker's comment: Poorly attempted. Many students could only identify weight of the plank. Many wrongly labelled the contact force on plank by man as weight of man.		
		(ii)	The moment of a force about a point is defined as the <u>product of the force and the perpendicular distance from the line of action of the force to that point</u>.	**B1**
		Marker's comment: Mostly well done. Some did not get any credit as their phrasing of "perpendicular distance" is vague and did not reflect the essence of definition of moment.		
		(iii)	Taking moment about A (anticlockwise moments) = (clockwise moments) $F_B \times 5.0 = 880 \times 0.5 + 200 \times 2.5$ $F_B = (440 + 500) / 5.0$ $= \underline{188}$ N	 **M1** **A1**
		Marker's comment: Mostly well done. Common mistakes include not factoring in the moment due to weight of man or weight of plank.		
	(b)	The <u>clockwise moment will increase due to the increase in perpendicular distance</u> (between CG & point A),		**B1**

		thus the <u>anticlockwise moment due to F_B will have to increase to maintain equilibrium</u> as well and magnitude of F_B will increase.		**B1** **A0**
		Marker's comment:		
		Poorly attempted. While many could correctly state that the CW moment will increase, they did not explain the reason for that increase. Similarly, they did not mention the corresponding increase in ACW to maintain rotational equilibrium and just drew link between increase in CW moment and hence increase in F_B.		
2	**(a)**		Area under *F-x* graph is work done in stretching bow. **<u>More potential energy</u>** is stored Arrows **<u>gain more kinetic energy, has less deviation from intended flight path / more accurate</u>** OR Arrows **<u>gain more kinetic energy</u>**, has **<u>further range</u>** OR Arrow **<u>hits target faster</u>**	**B1** **B1**
		Mostly well done. Most could identify that in stretching the bow more potential energy is stored and in turn identify reasonable advantage of that.		
	(b)	**(i)**	By counting squares under *F-x* graph, Elastic potential energy = area under *F-x* graph = 1.25 J × 65 = 81 J Acceptable to +/- 2 squares	**M1** **A1**
		Marker's comment: Mediocre attempt. While some students were able to correctly identify that the EPE is given by area under *F-x* graph, they were unable to give an accurate estimate as they did not take into consideration the scale of both axes. Some students also used the wrong method – using formula (EPE = ½ kx^2) to calculate without realising that F is not a constant.		
	(b)	**(ii)**	By Conservation of Energy, Loss in E_p = Gain in E_k for arrow $81=\frac{1}{2}\left(3.5\times10^{-2}\right)v^2$ v = 68.0 m s^{-1}	**M1** **A1**
		Marker's comment: Mostly well done. Ecf was given and most students were able to apply Principle of COE to calculate the speed of arrow. Students who were not awarded the full credit mostly had calculation error.		
3	**(a)**	For a body moving in uniform circular motion, there is a change in velocity as the **<u>direction of motion is changing</u>**. The rate of change of velocity gives rise to an acceleration. Since the **<u>change in velocity is directed towards the centre</u>** of the circular motion, the acceleration is also towards the centre. (**<u>acceleration is perpendicular to velocity)</u>** *Resultant force (centripetal force)		**B1** **B1**

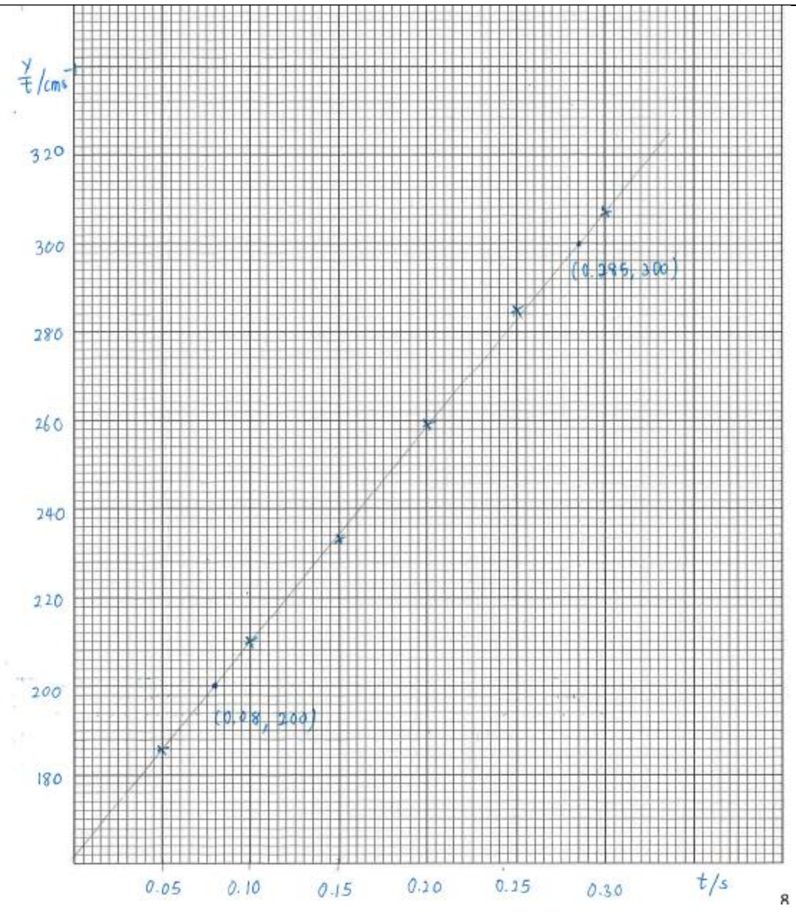
		Marker's comment: Mediocre attempt. Some students did not get any credit as they were merely describing circular motion and not explaining how the force allowed it to move in a circular path.		
	(b)	**(i)**	$a = r\omega^2 = (5.0\cos 60^\circ)\left(\frac{2\pi}{3.5}\right)^2$ $= 8.06\ m\ s^{-2}$	**M1** **A1**
		Marker's comment: Mediocre attempt. Some students did not know the correct formula for acceleration, other did not know that 3.5 s is the period and its role in the ccalculation of acceleration.		
		(ii)	$T\cos 60^\circ = ma$ $T = \frac{0.40 \times 8.06}{\cos 60^\circ} = \frac{0.40 \times 8.06}{0.5}$ $= 6.45\ \mathrm{N}$	**M1** **A1**
		Marker's comment: Mediocre attempt. Some students were unable to get the correct tension because they did not resolve it to equate the horizontal component to the centripetal force, instead they just equated the tension to centripetal force reflecting their lack of understanding of how vectors are computed.		
		(iii)	$L = mg + T\sin 60^\circ$ $= (0.40 \times 9.81) + 6.45\sin 60^\circ$ $= 9.51\ \mathrm{N}$	**M1** **A1**
		Marker's comment: Mediocre attempt. Many did not include the vertical component of tension in the downward vertical force, hence they only balanced lift force with weight of the toy plane.		
		(iv)	The tension in the wire is unchanged, since **centripetal force is unchanged**. The **vertical component of tension** together with the new lift force now **balance the weight of the toy plane**. Hence new lift force will **be lesser than before**.	**M1** **A1**
		Marker's comment: Poorly attempted. Many thought that the since the magnitude of tension and centripetal force remain unchanged, the lift force will remain unchanged too. For students who were able to correctly deduce that lift force will be lesser than before, they could not explain the reason convincingly.		
4	**(a)**	**(i)**	I = 1.8 + 0.60 = 2.4 A	**A1**
		Marker's comment: Generally well done.		
		(ii)	$V_X = V_Y + V_Z$	

			$0.60 \times 8.0 = 1.8\ (2.0 + R_Z)$ $R_Z = 0.67\ \Omega$	**C1** **A1**
		Marker's comment: Most are able to find the voltage and the current flowing through the resistor Z, thus enabling them to find Z resistance. Some wrongly equate the current in the two parallel branches to be the same (the voltage across the two parallel branches is the same).		
		(iii)	<u>*Either*</u> $E = Ir + I_X R_X$ $E = 2.4 \times 1.5 + 0.60 \times 8.0$ <u>*Or*</u> $E = Ir + I_Y R_Y + IR_Z$ $E = 2.4 \times 1.5 + 1.8(2.0+0.67)$ <u>*Or*</u> $\frac{1}{R_{eff}} = \frac{1}{8.0} + \frac{1}{2.0+0.67}$ $E = 2.4\left(1.5 + \frac{8.0 \times 2.67}{8.0+2.67}\right)$ $E = 8.4$ V	**C1** **A1**
		Marker's comment: Student are generally able to find the total resistance of the circuit and then the e.m.f. required.		
	(b)	$R = \frac{\rho l}{A}$ $\frac{R_X}{R_Y} = \frac{A_Y}{A_X}$ $\frac{8.0}{2.0} = \frac{A_Y}{A_X}$ $\frac{A_X}{A_Y} = 0.25$		**C1** **A1**
		Marker's comment: Students are generally able to compute the ratio of the area from the ratio of the resistance. Some are unable to manipulate the relationship between the resistance and the area while other wrongly thought that the resistance is inversely proportional to the square of the area.		
	(c)	<u>*Either*</u> $\text{Efficiency} = \frac{\text{output power}}{\text{input power}} = \frac{IV}{IE}$ $= \frac{0.60 \times 8.0}{8.4}$ <u>*Or*</u> $\frac{1}{R_{eff}} = \frac{1}{8.0} + \frac{1}{2.0+0.67}$ $R_{eff} = 2.00\ \Omega$		**M1**

		Efficiency $= \dfrac{\text{output power}}{\text{input power}} = \dfrac{IV}{IE} = \dfrac{I^2 R_{eff}}{I^2\left(R_{eff}+r\right)}$ $= \dfrac{I^2 \times 2.0}{I^2\left(2.0+1.5\right)}$ Efficiency = 57.1%	A1
		Marker's comment: Not well done. It is surprising that many did not use power to compute efficiency. Some who tries to use voltage to compute efficiency should illustrate how the current in the output and input power is the same.	
5	**(a)**	The direction of the magnetic force acting on the electron is always normal to its velocity. The magnitude of the magnetic force is constant. Hence the magnetic force provides for the centripetal force, leading to the electron following a circular path.	**M1** **M1** **A0**
		Marker's comment: Poorly done. Most are not aware that the question is asking how this scenario fulfil the conditions of circular motion. Many wasted their efforts to find the direction of the magnetic force and then simply state that this force acts as a centripetal force, without explaining why the force lead to circular motion.	
	(b)	Increase in KE = Decrease in PE $\frac{1}{2} mv^2 = qV$ Since $p = mv$, $\dfrac{1}{2}mv^2 \times \dfrac{m}{m} = qV$ $\dfrac{p^2}{2m} = qV$ $p = \sqrt{\left(2mqV\right)}$	**M1** **M1** **A0**
		Marker's comment: Poorly done with many not attempting it. Students did not understand that the decrease in potential energy leads to increase in kinetic energy (and also momentum).	
	(c)	The magnetic force acting on the electron provides for its centripetal force. $F_c = ma_c$ $Bqv = \dfrac{mv^2}{r}$ $p = mv = Bqr$ Given that $p = \sqrt{\left(2mqV\right)}$, $p = \sqrt{\left(2mqV\right)} = Bqr$ $\sqrt{2 \times 9.11 \times 10^{-31} \times 1.6 \times 10^{-19} \times 120} = B \times 9.11 \times 10^{-31} \times 0.074$ $B = 5.0 \times 10^{-4}$ T	**B1** **C1** **C1** **A1**
		Marker's comment: Poorly done. Many did not use the hint given in (a) to solve this circular motion question. They either left the question blank or use wrong methods, e.g. velocity selector, magnetic force on a conductor is used to solve	

		this question. Those who use the magnetic force on a charge as the centripetal force manage to solve the question.	
	(d)	When the potential difference *V* is increased, the momentum of the electron increased. Since the momentum of the electron is directly proportional to the radius (or $p = Bqr$), the radius of the circular path increases.	**M1** **M1** **A1**
		Marker's comment: Poorly done. Only a few are able to make the connection that the increase in potential difference used to accelerate the electron increases its momentum / speed. However, they need to properly account how the increase in velocity affects both the magnetic force and the centripetal acceleration, and hence increases the radius of circular path.	
6	**(a)**	$\Delta x / \Delta t$ Suitable calculation using a pair of values of *x* and corresponding *t* values to give an average of 2.2 m s^{-1} (± 0.5 m s^{-1}) Valid reasons for choice could be • Larger values are more reliable/ accurate • Use of differences eliminates zero errors if any	**A1** **B1**
		Marker's comment: Majority of students did not use pair or values for calculation and many gave the reason for their choice as finding the average values which is trivial.	
	(b)	**(i)** y/t: 186, 210, 233, 259, 284, 307	**M1** **A1**
		Marker's comment: This part was well done. Most common problem was incorrect number of significant figures. Either 2 or 3 s.f are acceptable (the least s.f was 2 -time and one more s.f is acceptable).	
		(ii) Graph mark • Good best fit line • All points plotted correctly	**M1** **M1**

y/t
186
210
233
259
284
307



Marker's comment:

Many students were able to plot the points to good accuracy. Drawing a good best fit line is one with almost equal number of data points above and below the line.

		(iii)	k = Gradient = 495 cm s^{-2} (± 25 cm s^{-2}) unit of k u = y-intercept = 162 cm s^{-1} (± 4 cm s^{-1}) unit of u	**A1** **A1** **A1** **A1**

Marker's comment:

Most of the values are calculated for gradient and y-intercept (can be read off or calculated) to be within range. There were a few students who made some calculation error and did not get the mark.

	(c)	**(i)**	u : initial vertical component of velocity	**B1**

Marker's comment:

$$\frac{y}{t} = u + kt$$

$s_y = u_y t + ½ gt^2$

This is a projectile motion question. However students did not make the connection with the kinematics equation and many incorrectly guess u as the initial velocity.

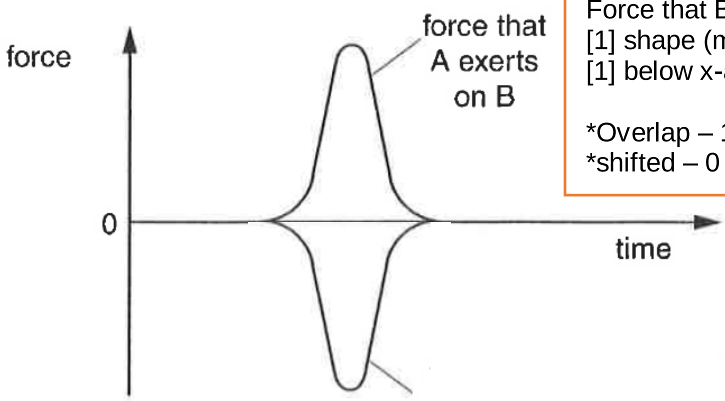
		(ii)	k : ½ g	**B1**

Marker's comment:

		Students did not make the connection to the kinematics equation.	
	(d)	Vertical component (y –intercept) = 162/100 = 1.62 m s^{-1} Horizontal component = 2.2 m s^{-1} $v^2 = (162/100)^2 + 2.2^2$ v = 2.7 m s^{-1} (± 0.1 m s^{-1})	**M1** **A1**
		Marker's comment: Stronger ability students were able to make the connection with the horizontal and vertical initial components.	
	(e)	As steel ball has greater mass / weight / density , the air resistance is insignificant compared to weight (when speed is low).	**B1** **B1**
		Marker's comment: Generally, reasonable answers are acceptable. It should also be noted that air resistance is a preferred term compared to wind.	

SECTION B

7	**(a)**	**(i)**	Principle of Conservation of Linear Momentum states that the total momentum of a system of interacting objects remains constant provided no resultant external force act on the system.	**B1** **B1**
		Marker's comment: It is evident that many students were not able to recall the full definition.		
		(ii)	$F = \frac{\Delta p}{t}$ where F is the force, Δp is the change in linear momentum and t is the time taken. (constant) Force is the rate of change in linear momentum. Change in linear momentum is (constant) force x time.	**B1**
		Marker's comment: It is again disappointing to see many students unable to recall the correct terms and relationship.		

	(b)	(i)	 Force that B exerts on A [1] shape (magnitude) [1] below x-axis (direction) *Overlap – 1mark *shifted – 0 mark	B1 B1
		Marker's comment: Many students were able to draw the mirror image paying good attention to the details in terms of the shape and magnitude.		
		(ii)	The forces are equal in magnitude and opposite in direction at any time, hence there is not net force acting on the system (A & B). The area under the F-t graph represent the change in momentum, since the graph are mirror image of each other, it can be concluded that the total momentum is constant. (positive & negative equal areas; sum of area zero; at the same time)	B1 B1 B1
		Marker's comment: Only the stronger ability students were able to relate the area under the graph to the change in momentum. Most students quoted Newton's third law without making any reference to the graph sketched.		
	(c)	(i)	a head-on collision means that the point of impact is on the straight line connecting the center of gravity of each of the objects (collinear). OR before and after collision the objects move along the same line. *Opposite direction (0 mark) *moving towards each other in a straight line (0 mark)	B1
		Marker's comment: *put in wrong answer for students' reference Many students did not understand the meaning of heads-on.		
		(ii)	1. $\Delta p = F\Delta t = 72000\ (0.25) = 18\ 000$ Ns $\Delta v_{car} = 18000 / 1200 = 15$ m s^{-1} Car gains momentum	M1 A1 A1
			2. $\Delta v_{truck} = 18000/12000 = 1.5$ m s^{-1} Truck loses momentum	A1 A1
		Marker's comment: Many students recognize that car gains momentum while truck loses momentum but were not able to do the calculations.		

	(d)	The force of collision being constant is not realistic.		**B1**
		Marker's comment: This part was reasonable well done. Some incorrect answers suggested that the mass of the truck was too large (12000 kg is a reasonable estimate for truck and 1200 kg is also reasonable estimate for car).		
	(e)	These features prevent passengers from being flung forward (minimise injuries – safety). Safety belts and air bags increase impact time (provide a backward force to decelerate the passenger over a longer time), thus reduce the magnitude of force exerted on the passengers. OR Safety belts and air bags provide a backward force to decelerate the passenger over a longer time, thus reduce the magnitude of force exerted on the passengers.		**B1** **B1**
		Marker's comment: Many students were able to get the first mark for suggesting the feature that prevent passengers from being flung forward. The second mark was often not awarded as student need to mention both increase in impact time **and** hence a reduction in impact force.		
	(f)	**(i)**	Weight of car, type/condition of road surfaces/ material of tyres of car Or any other reasonable answers	**B2**
		Marker's comment: This part was well done. Many students were able to give good answers.		
		(ii)	Crumple zone of car, centre of gravity of car *shape of car, material of car body (how does it affects the safety) *Design of car – too vague *it shouldn't be too vague	**B1**
		Marker's comment: This part was well done. Many students were able to give interesting reasonable suggestions.		