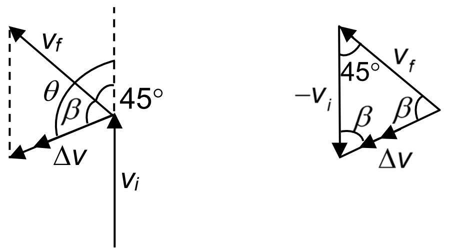
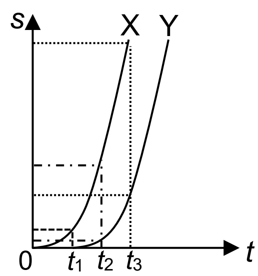
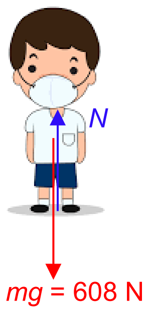
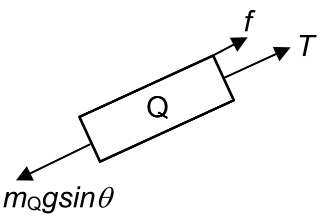
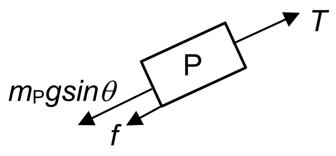
Raffles Institution
Year 5-6 Physics Department

2021 Year 5 H2 Physics Term 3 Common Test Solution

Section A

Qn	Ans	Solution
1	A	 change in velocity, $\Delta v = v_f - v_i$ Since $\lvert -v_i \rvert = \lvert v_f \rvert = v$, vector triangle is an isosceles triangle. $\beta = \dfrac{180° - 45°}{2} = 67.5°$ $\lvert \Delta v \rvert^2 = \lvert -v_i \rvert^2 + \lvert v_f \rvert^2 - 2\lvert -v_i \rvert \lvert v_f \rvert \cos 45°$ $= v^2 + v^2 - 2v^2 \cos 45°$ $= 2v^2 - 2v^2 \left(\dfrac{\sqrt{2}}{2} \right)$ $= v^2 \left(2 - \sqrt{2} \right)$ $\lvert \Delta v \rvert = 0.765v = 0.77v$ $\theta = 45° + 67.5° = 112.5°$
2	C	mass of a donut ≈ 50 g outer diameter ≈ 8 cm inner diameter ≈ 2 cm height ≈ 3 cm density $= \dfrac{\text{mass}}{\text{volume}} = \dfrac{0.050}{\pi\left[\left(\dfrac{0.08}{2}\right)^2 - \left(\dfrac{0.02}{2}\right)^2\right](0.03)} = 354 \text{ kg m}^{-3} = 3.54 \times 10^2 \text{ kg m}^{-3}$
3	D	Both X and Y experience the same acceleration of free fall *g* regardless of their masses. vertical displacement, $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}gt^2 = \frac{1}{2}gt^2$ Using the graph of *s* against *t*, where *t* = 0 is the time X is dropped, compare the displacements of X and Y at t_1, t_2 and t_3. The distance between X and Y increases with time and this is independent of their masses. 

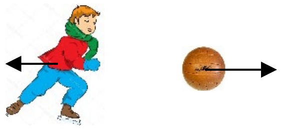
4	**A**	Option A: At the mid-point of the graph, the gradient is not zero, which indicates that the speed of the object is non-zero at the highest point, which is incorrect. Options B, C and D: Each graph shows that velocity is zero momentarily at the highest point of the motion and the motion is symmetrical about the highest point. It also shows that the object reverses its motion at the highest point and returns to its original position.
5	**B**	$v^2 = u^2 + 2as$ $a = \dfrac{20^2 - 10^2}{2(100)} = 1.5 \text{ m s}^{-2}$
6	**C**	At $t = 8.0$ s, $a = \dfrac{8.0 - 0}{6.0 - 10.0} = -2.0 \text{ m s}^{-2}$ t = 8.0 s $N - mg = ma$ $N = m(a+g) = 62(-2.0 + 9.81) = 484$ N where N is the force on the passenger by the weighing scale. By Newton's third law, the force on the weighing scale by the passenger is also 484 N in magnitude. Hence the weighing scale will read 484 N.  Answer can be obtained by analysing the upwards motion of the elevator: Between 0 s to 2.0 s, the elevator is accelerating upwards. Hence the resultant force acting on the passenger is upwards. This implies $N > mg$. Option A is incorrect. Between 2.0 s and 6.0 s, the elevator is moving at constant velocity upwards. Hence the resultant force on the passenger is zero. This implies $N = mg$. Option B is incorrect. Between 6.0 s and 10.0 s, the elevator is decelerating upwards. Hence the resultant force acting on the passenger is downwards. This implies $N < mg$. Option D is incorrect.
7	**C**	<u>Consider forces parallel to plane on Q:</u>  $m_Q g \sin\theta - T - f = m_Q a$ ... (1) <u>Consider forces parallel to plane on P:</u>  $T - m_P g \sin\theta - f = m_P a$ ... (2) (1) + (2): $(m_Q - m_P) g \sin\theta - 2f = (m_Q + m_P) a$ $(0.900 - 0.100)(9.81)\sin\theta - 2(0.10) = (0.900 + 0.100)(3.0)$ $\theta = 24°$

<table>
<tr>
<td>8</td>
<td>C</td>
<td>
By conservation of momentum, taking direction to the right as positive

$p_{\text{before Charlie throws the ball}} = p_{\text{after Charlie throws the ball}}$

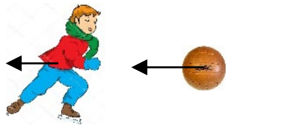
$$0 = m_{ball}u_{ball} + m_{Charlie}\left(-u_{Charlie}\right)$$

$$m_{Charlie}u_{Charlie} = m_{ball}u_{ball} \qquad \text{..........} \ (1)$$



$$p_{\text{before Charlie catches the ball}} = p_{\text{after Charlie catches the ball}}$$

$$m_{ball}\left(-u_{ball}\right) + m_{Charlie}\left(-u_{Charlie}\right) = \left(m_{ball} + m_{Charlie}\right)\left(-v\right) \qquad \text{........} \ (2)$$



Subst. (1) into (2):

$$2m_{ball}u_{\ ball} = \left(m_{ball} + m_{Charlie}\right)\left(v\right)$$

$$v = \frac{2m_{ball}u_{\ ball}}{\left(m_{ball} + m_{Charlie}\right)} = \frac{2(1.5)(2.5)}{(1.5+60)} = 0.122 = 0.12 \text{ m s}^{-1}$$
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<td>9</td>
<td>B</td>
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Consider the free-body diagram of pail and block together.

Since the blocks in both pails P and Q are floating, the weight of the water each block displaces is equal to the weight of the block.

Upwards force on pail & block by weighing scale
= weight of pail & remaining water + weight of block
= weight of pail & remaining water + weight of water displaced (or upthrust)
= weight of pail & water filled to the brim

Hence the weight of each of the pails P and Q is equal to the weight of a pail filled to the brim with water only.

For pail R, since the block is on the bottom of the pail,

Upwards force on pail & block by weighing scale
= weight of pail & remaining water + weight of block
= weight of pail & remaining water + [weight of water displaced (or upthrust)
+ normal contact force on block by pail]
= weight of pail & water filled to the brim + normal contact force on block by pail

Hence the weight of pail R is greater than the individual weight of P and Q, due to the normal contact force on the block by the pail.
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<tr>
<td>10</td>
<td>B</td>
<td>
For rotational equilibrium about the pivot, the sum of the clockwise moments must be equal to the sum of the anticlockwise moments due to the weight of each material part. The location of the centre of gravity (CG) of the composite rod can also be estimated. The pivot must be below the CG for the rod to be in rotational equilibrium (balanced).

For options C and D, the CG is at the mid-point of the rod so the pivot is placed correctly below the CG to balance the rod.

For option A, the CG is to the right of the mid-point of the rod as the denser material Q is concentrated to the right. The pivot is also positioned to the right of the mid-point of the rod. There is a possibility that the rod is balanced.
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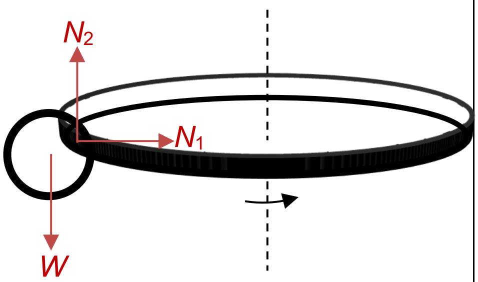
		For option B, the CG is also to the right of the mid-point of the rod since the denser material Q is concentrated to the right, but the pivot is at the mid-point. Hence, rotational equilibrium cannot be established and the rod is not balanced.
11	**D**	Work done by *F* is given by the area under the *F*–*s* graph. From 0 to 8 m, *F* is applied in the same direction as *s* (both positive). Hence there is positive work done by *F* on the system which causes the work done on the system and the kinetic energy of the object to increase. From 8 m to 10 m, *F* is applied in the opposite direction to *s* (*F* negative, *s* positive) and the motion of the object. Hence there is negative work done by *F* which causes the work done on the system and the kinetic energy of the object to decrease. The amount of positive work done is greater than the amount of negative work done, hence overall work done remains positive and the kinetic energy of the object increases overall.
12	**B**	By the conservation of energy, increase in K.E. + work done against the retarding force = decrease in G.P.E. $\left(\frac{1}{2}mv^2 - 0\right) + f\left(\Delta h_2\right) = mg\left(\Delta h_1 + \Delta h_2\right)$ $v = \sqrt{\frac{2}{m}\left[mg\left(\Delta h_1 + \Delta h_2\right) - f\left(\Delta h_2\right)\right]}$ $= \sqrt{\frac{2}{1.0}\left[(1.0)(9.81)(10 + 0.50) - 160(0.50)\right]}$ $= 6.78 = 6.8 \text{ m s}^{-1}$
13	**D**	For vertical equilibrium, an upward normal contact force N_2 on the small ring that is opposite to the weight of the small ring must be present. The frictional force in the vertical direction is not large enough to support the weight. For the small ring to undergo circular motion, there must be a force towards the vertical axis to provide for the centripetal force. The normal contact force N_2 on the ring must be present to provide for this.  The frictional force along the surfaces (tangential direction) of the ring allows the small ring to rotate together with the big ring, but does not contribute to the centripetal force. Hence, the small ring should hang down and outwards, so that its top and side touches the big ring.

14 **A**

For the same coin placed on the same turntable, the maximum frictional force on the coin is a constant. This frictional force provides for the centripetal force as the object undergoes circular motion when the turntable rotates.

$$F_{\text{max}} = m\omega_{\text{max}}{}^2 r$$

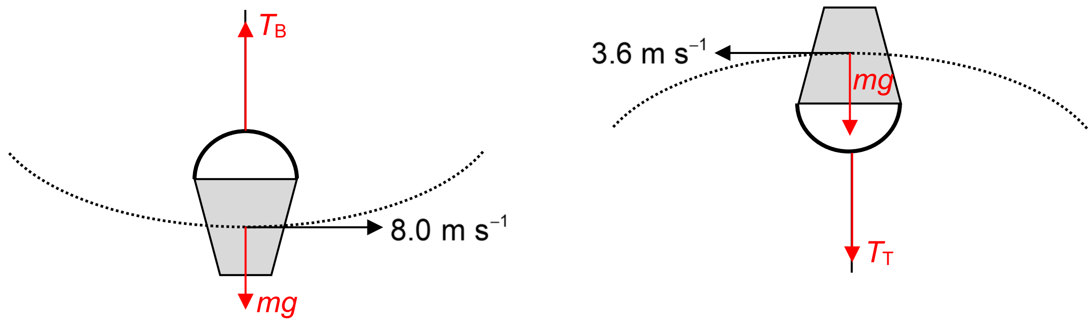
$$\omega_{\text{max}} = \sqrt{\frac{F_{\text{max}}}{mr}}$$

Since F_{max} and m are constants,

$$\omega_{\text{max}} \propto \frac{1}{\sqrt{r}}$$

Hence a graph of ω_{max} and r will have $\omega_{\text{max}} = 0$ and $r = 0$ as asymptotes.
Furthermore, as one quantity increases, the other decreases and vice versa.

15 **C**



$$T_B - mg = \frac{mv_B{}^2}{r}$$

$$T_B = \frac{mv_B{}^2}{r} + mg$$

$$T_T + mg = \frac{mv_T{}^2}{r}$$

$$T_T = \frac{mv_T{}^2}{r} - mg$$

Difference in tension:

$$\begin{aligned} T_B - T_T &= \left(\frac{mv_B{}^2}{r} + mg\right) - \left(\frac{mv_T{}^2}{r} - mg\right) \\ &= \frac{mv_B{}^2}{r} - \frac{mv_T{}^2}{r} + 2mg \\ &= 1.2\left(\frac{8.0^2}{1.3} - \frac{3.6^2}{1.3} + 2(9.81)\right) \\ &= 70.66 = 71\ \text{N} \end{aligned}$$