HOLY CROSS COLLEGE
Life to the Full

11 PHYSICS ATAR
TEST 2: MOTION

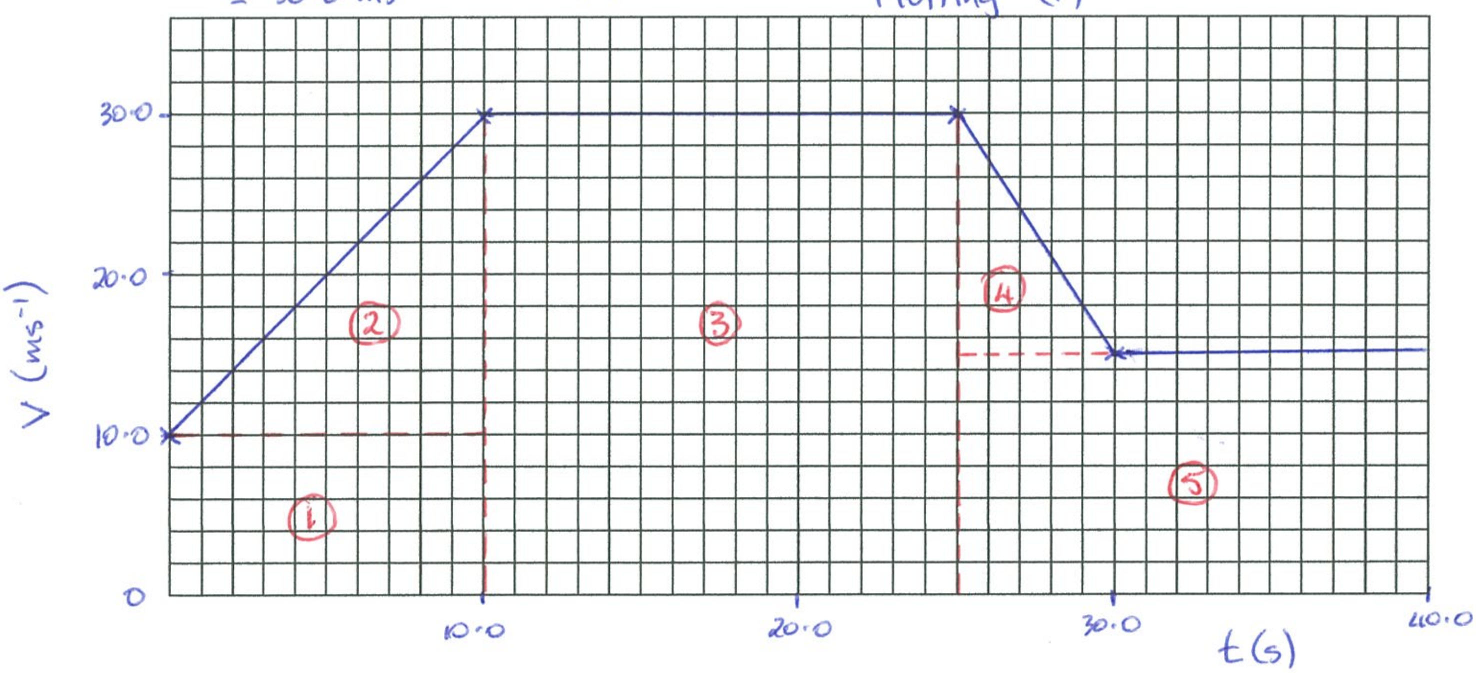
NAME: SOLUTIONS MARK: ~~26~~ 51

1. A motorbike, which is travelling at a 10.0 ms^{-1} along a straight road, accelerates at 2.00 ms^{-2} for 10.0 s. It maintains this velocity for 15.0 s before braking uniformly for 5.00 s to reduce speed to 15.0 ms^{-1}. The motorbike continues at this velocity along the road.

   (a) Draw a velocity-time graph for the motion described. ***The time scale needs to run to at least 40.0 s.*** The scales need to be drawn accurately. (4 marks)

$v = u + at$
$= 10.0 + (2.00)(10.0)$ (1)
$= 30.0\ ms^{-1}$

Scales (1)
Labels + units (1)
Plotting (1)



   (b) Determine the deceleration experienced by the rider whilst reducing speed.

$\text{gradient} = \dfrac{(15.0 - 30.0)}{(30.0 - 25.0)}$ (1)

$= -3.00\ ms^{-2}$. (1)

$\therefore$ Deceleration = 3.00 ms^{-2} backwards. (1)

[Can also use v, u, a, t, s].

(3)

(c) How far has the rider travelled after 40.0 s?

s = area under the graph

$= (10.0)(10.0) + \frac{1}{2}(10.0)(20.0) + (15.0)(30.0) + \frac{1}{2}(5.00)(15.0) + (15.0)(15.0)$ (3)

$= 9.125 \times 10^2$ m

$\therefore$ $\underline{s = 9.12 \times 10^2 \text{ m}}$ (1)

(4)

2. A hot air balloon in central Australia is rising at a constant speed of 7.00 ms^{-1} at a height of 1.50 x 10^2 m above the ground. At this point, a passenger accidentally released a sand bag on the outside of the basket and it falls to the ground.

(a) Does the bag start to fall towards the ground immediately it is released, or does it continue to move upwards initially? Explain your answer briefly.

- Continues to move upwards at 7.00 ms^{-1} initially. (1)
- Once free, it slows under gravity as it moves upwards. (1)

(2)

(b) Calculate the velocity of the bag at impact with the ground.

$\downarrow$ +ve.

$v = ?$

$u = -7.00 ms^{-1}$

$a = 9.80 ms^{-2}$

$t = ?$

$s = 1.50 \times 10^2$ m

$v^2 = u^2 + 2as$

$= (-7.00)^2 + 2(9.80)(1.50 \times 10^2)$ (1)

$= 2.989 \times 10^3$ (1)

$\Rightarrow$ $\underline{v = 54.7 ms^{-1} \text{ down}}$. (1)

(3)

(c) How long does it take the bag to reach the ground?

$\downarrow$ +ve

$$v = u + at \qquad (1)$$

$$\Rightarrow 54.7 = -7.00 + (9.80)t \qquad (1)$$

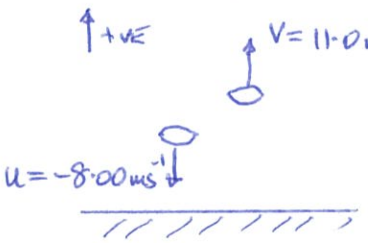
$$\Rightarrow t = 6.296 \text{ s}$$

$$\therefore \underline{t = 6.30 \text{ s}} \qquad (1)$$

(3)

3. In the game of Australian Rules football, the central umpire starts the game by bouncing the 464 g ball on a bounce pad in the middle of the oval. An umpire throws the ball down at 8.00 ms^{-1} and it rebounds at 11.0 ms^{-1} after being in contact with the pad for 0.115 s.

(a) What is the change in momentum of the ball?



$$\Delta v = v - u$$
$$= 11.0 - (-8.00) \qquad (1)$$
$$= 19.0 \text{ ms}^{-1} \text{ upwards} \qquad (1)$$

$$\Delta p = m\Delta v$$
$$= (0.464)(19.0) \qquad (1)$$
$$= \underline{8.82 \text{ kgms}^{-1} \text{ upwards}}. \qquad (1)$$

(4)

(b) Calculate the impulsive force that acted during the time of impact.

$$F = \frac{\Delta p}{t} \qquad (1)$$

$$= \frac{8.82}{0.115} \qquad (1)$$

$$= \underline{76.7 \text{ N upwards}} \qquad (1)$$

(3)

(c) Umpires find it very difficult to bounce the ball high enough if they have to do so on the softer grass around the playing area. Using your knowledge of Physics' principles, explain why this is so.

- From $F = \frac{\Delta p}{t}$, $F \propto \frac{1}{t}$ $(1\frac{1}{2})$
- On softer ground, the time of impact is longer. $\Rightarrow$ F is smaller. $(1\frac{1}{2})$

(3)

4. An iron ore train is being assembled in Port Hedland, ready to be sent to pick up ore from Tom Price. Two engines of combined mass 5.10×10^5 kg, moving at 1.00 ms^{-1}, shunt and join with 10 empty ore cars, each of mass 2.40×10^3 kg.

(a) Calculate the speed of the combination immediately after the impact.

Take forwards as +ve.

$$\Sigma p_i = \Sigma p_f$$

$$\Rightarrow m_1 v_1 + m_2 v_2 = (m_1 + m_2)v \quad (2)$$

$$\Rightarrow (5.10 \times 10^5)(1.00) + 0 = (5.10 \times 10^5 + 2.40 \times 10^4)v \quad (1)$$

$$\Rightarrow \underline{v = 0.955\ ms^{-1}\ \text{forwards}}. \quad (1)$$

(4)

(b) Is mechanical energy conserved in this collision? Justify your answer by calculation.

$$\Sigma E_K(\text{initial}) = \frac{1}{2}m_1u_1^2 = \frac{1}{2}(5\cdot10\times10^5)(1\cdot00)^2 \quad (1)$$

$$= 2\cdot55\times10^5 \text{ J}$$

$$\Sigma E_K(\text{final}) = \frac{1}{2}(m_1+m_2)v^2 = \frac{1}{2}(5\cdot10\times10^5 + 2\cdot40\times10^4)(0\cdot955)^2$$

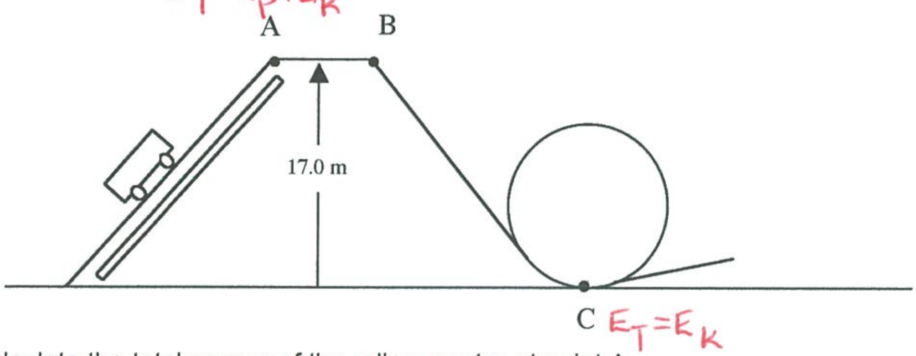
$$= 2\cdot44\times10^5 \text{ J} \quad (1)$$

$\therefore$ Mechanical energy is not conserved. (1)

(3)

5. An electric motor rated at 4.90 x 10^5 W is used to pull a roller coaster of total mass 6.70 x 10^3 kg up to a height of 17.0 m, as shown in the diagram. At point A, the coaster has a speed of 1.50 ms^{-1}, which it maintains to point B.

$E_T = E_p + E_K$



$E_T = E_K$

(a) Calculate the total energy of the roller coaster at point A.

$$E_T = E_p + E_K \quad (1)$$

$$= mgh + \frac{1}{2}mv^2 \quad (1)$$

$$= (6\cdot70\times10^3)(9\cdot80)(17\cdot0) + \frac{1}{2}(6\cdot70\times10^3)(1\cdot50)^2 \quad (1)$$

$$= \underline{1\cdot12\times10^6 \text{ J}} \quad (1)$$

(4)

(b) Theoretically, how long would it take the motor to lift the roller coaster up to point A?

$$P = \frac{E_T}{t}$$

$$\Rightarrow t = \frac{E_T}{P}$$

$$= \frac{1.12 \times 10^6}{4.90 \times 10^5} \quad (1)$$

$$= \underline{2.29\,s} \quad (1)$$

(2)

(c) If the coaster then rolls down to point C, what would be its speed?

$$E_T = E_K = \frac{1}{2}mv^2$$

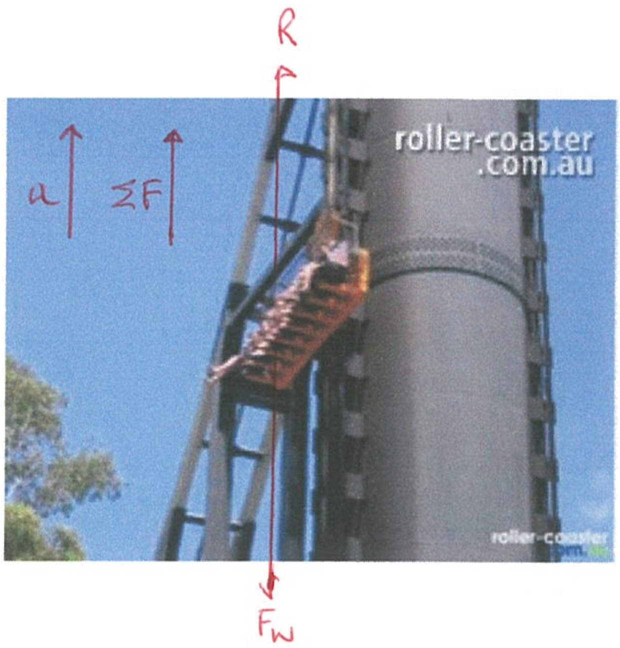
$$\Rightarrow v = \sqrt{\frac{2E_T}{m}} \quad (1)$$

$$= \sqrt{\frac{2(1.12 \times 10^6)}{(6.70 \times 10^3)}} \quad (1)$$

$$= \underline{18.3\,ms^{-1}} \quad (1)$$

(3)

6. At Dream World on the Gold Coast, the Giant Drop carries groups of 8 people to a height of 1.20×10^2 m before allowing them to "free fall" to 20.0 m before decelerating them. Assume the combined mass of the 8 people and the bench they sit on is 8.00×10^2 kg.



(a) Calculate the force required from the internal lift mechanism to move the people upwards at a constant speed.

If $a = 0 \Rightarrow \Sigma F = 0$

$\Rightarrow R = F_W$ (1)

$= mg$

$= (8.00 \times 10^2)(9.80)$ (1)

$= \underline{7.84 \times 10^3 \text{ N upwards}}$. (1)

(3)

(b) If the deceleration at the bottom of the ride is equivalent to "3.60 g" (3.60 times the acceleration due to gravity), determine the force exerted by the internal mechanism.

$\Sigma F = R - F_W$

$a = (3.60)(9.80)$

$= 35.28 \text{ ms}^{-2}$ upwards

$\Rightarrow R = \Sigma F + F_W$ (1)

$= ma + mg$

$= (8.00 \times 10^2)(35.28 + 9.80)$ (1)

$= \underline{3.61 \times 10^4 \text{ N upwards}}$. (1)

(3)