2A/B PHYSICS
ASSIGNMENT 3: NEWTON'S LAWS, WORK AND ENERGY

NAME: SOLUTIONS **DUE DATE:** ________ **TOTAL:** $\frac{\quad}{38}$

1. Bulk carriers are used extensively to move large amounts of iron ore around the world. Typically the mass of such behemoths is around 200,000 tonnes (fully loaded). It is important that the engines of these carriers are turned off well out to sea as they approach port.

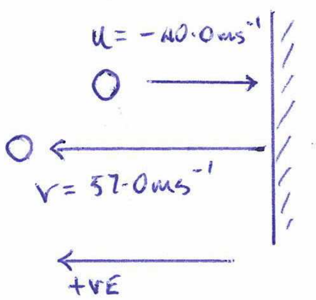
   Giving mention to the Physics principles involved, explain why this method is employed when these carriers enter port.

   - Due to their large mass, bulk carriers have enormous inertia. (1)
   - They continue to move with their velocity for a long time. (1)
   - The wind and waves exert a force to overcome this inertia and change the ship's momentum. (2)

(4)

2. During a tennis game, a player hits the ball at 40.0 ms^{-1} (horizontal velocity) directly towards her opponent who hits it straight back at 57.0 ms^{-1}. The 55.0 g ball is in contact with the racquet for 0.115 s.

   (a) Determine the change in velocity of the ball.



$$\Delta v = v - u$$
$$= 57.0 - (-40.0) \quad (2)$$
$$= \underline{97.0\ ms^{-1}\ \text{away from the racquet}}. \quad (1)$$

(3)

(b) What force is exerted by the racquet onto the ball?

$$I = Ft = m\Delta v = \Delta p$$

$$\Rightarrow F = \frac{m\Delta v}{t}$$

$$= \frac{(0.0550)(97.0)}{0.115} \quad (1)$$

$$= 46.39 \text{ N}$$

$\therefore$ $\underline{F = 46.4 \text{ N away from the racquet.}}$ (1)

(2)

(c) What impulse is acting?

$$I = Ft$$

$$= (46.4)(0.115) \quad (1)$$

$$= 5.336 \text{ Ns}$$

$\therefore$ $\underline{I = 5.34 \text{ Ns away from the racquet.}}$ (1)

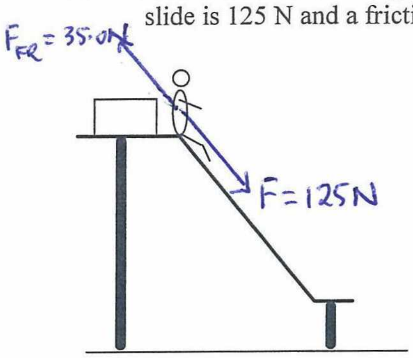
(2)

(d) How would you expect the force exerted to change if a racquet with "loose strings" (rather than "tight strings") was used? Explain your answer using the Physics principles involved.

- Loose springs would increase the impact time. (1)
- Since $F = \frac{\Delta p}{t}$, increasing t would decrease the force F. (2)

(3)

3. A child of mass 25.0 kg slides down a playground slide from rest in 3.20 s. The force acting down the slide is 125 N and a frictional force of 35.0 N acts against the child.



(a) Calculate the acceleration of the child down the slope.

Take down the slide as +ve.

$\Sigma F = ma$

$\Rightarrow 125 - 35.0 = (25.0)a$

$\Rightarrow$ $\underline{a = 3.60\ ms^{-2}$ down the slide$}$.

(3)

(b) Determine the velocity of the child at the bottom of the slide.

$v = ?$
$u = 0.0\ ms^{-1}$
$a = 3.60\ ms^{-2}$
$t = 3.20\ s.$
$s = ?$

$v = u + at$

$= 0 + (3.60)(3.20)$

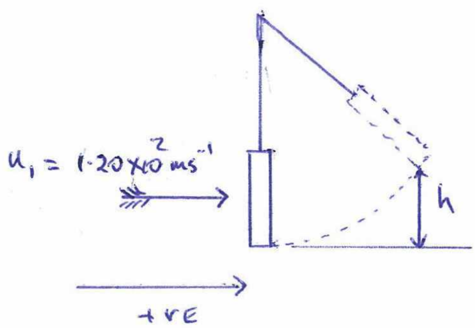
$= 11.52\ ms^{-1}.$

$\therefore$ $\underline{v = 11.5\ ms^{-1}$ down the slope$}$.

(2)

4. An archer fires an arrow (of mass 96.0 g) with a velocity of $1.20 \times 10^2\ ms^{-1}$ into a target (of mass 1.50 kg) hanging by two light pieces of string from the branch of a tree.

(a) If the arrow embeds into the target, what is the velocity of the target immediately after impact?



(a)

$\Sigma p_i = \Sigma p_f$

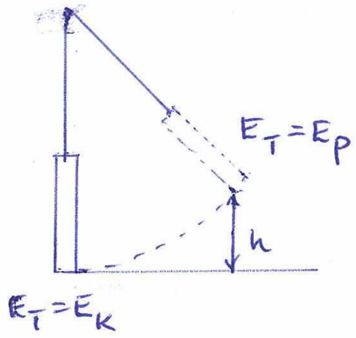
$\Rightarrow m_1u_1 + m_2u_2 = (m_1 + m_2)v$ (1)

$\Rightarrow (0.0960)(1.20 \times 10^2) + 0 = (0.0960 + 1.50)v$ (1)

$\Rightarrow$ $\underline{v = 7.22\ ms^{-1}$ forwards$}$. (1)

(3)

(b) How high (vertically) does the target and arrow swing?
(HINT: Consider the conservation of energy.)



E_K (bottom) $= E_P$ (top)

$\Rightarrow \frac{1}{2}\cancel{m}v^2 = \cancel{m}gh$ (1)

$\Rightarrow h = \frac{v^2}{2g}$

$= \frac{(7.22)^2}{2(9.80)}$ (1)

$= \underline{2.66 \text{ m}}$ (1)

(3)

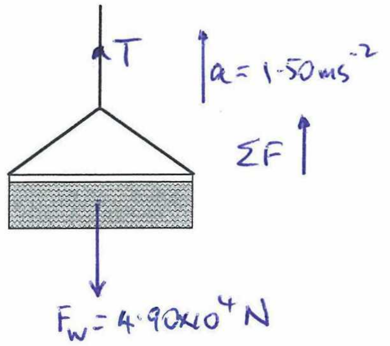
(c) In reality, will the target and arrow swing this high? Explain your answer in terms of the Physics' principles involved.

- No. (1)
- Energy is lost as heat and sound: (1)
  1. as the arrow enters the board.
  2. as the board swings against the air. (1)

(3)

5. On a building site in Perth, a crane lifts a 1.00 tonne cradle full of 4.00 tonnes of cement off the ground to take it up to the 25th floor. It accelerates upwards from the ground at 1.50 ms^{-2} for 4.00 s before maintaining its speed up to the 20th floor. It then decelerates uniformly to a stop at the 25th floor. The total time taken from the ground is 17.4 s.

(a) Compare the tension in the single cable holding the cradle when it is accelerating upwards and when it has constant speed.



ACCELERATION

$\Sigma F = T - F_W$

$\Rightarrow \quad T = \Sigma F + F_W$

$= ma + mg$ (1)

$= (5.00 \times 10^3)(1.50 + 9.80)$ (1)

$= 5.65 \times 10^4$ N (1)

CONSTANT VELOCITY $\quad \Sigma F = 0$

$\Rightarrow \quad T = F_W$

$= mg$

$= (5.00 \times 10^3)(9.80)$

$= 4.90 \times 10^4$ N (1)

$\therefore$ Tension (when accelerating) is 1.15 times that when travelling at constant velocity. (1)

(5)

(b) ***Estimate*** the work done by the crane motor in lifting the cradle up to the 25th floor.

ESTIMATION: Each floor is 2.50 m high. (1)

$W_{done} = \Delta E_p = mgh$

$= (5.00 \times 10^3)(9.80)(25.0 \times 2.50)$ (1)

$= 3.06 \times 10^6$ J (1)

(3)

(c) ***Estimate*** the average power expended by the motor.

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

$$= \frac{3.06 \times 10^6}{17.4} \quad (1)$$

$$= \underline{1.76 \times 10^5 \text{ W}} \quad (1)$$

(2)