ARANMORE CATHOLIC COLLEGE

PHYSICS 3A3B - 2010

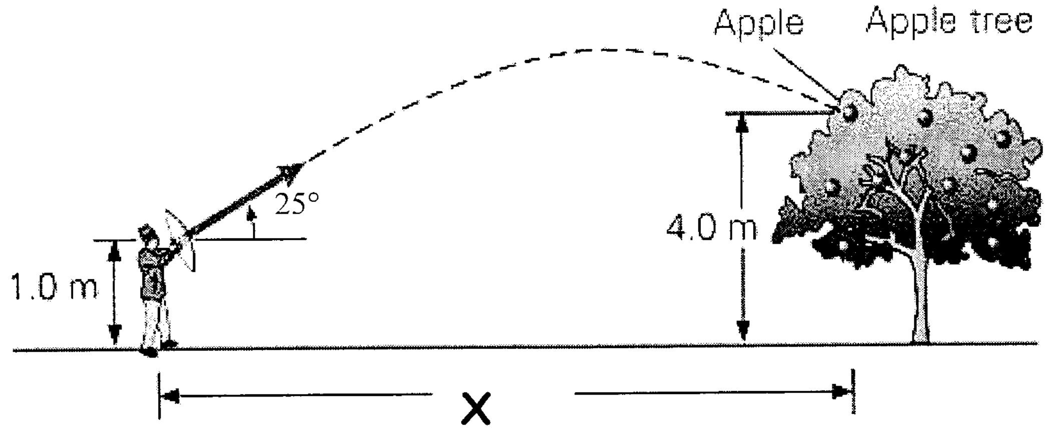
ASSIGNMENT #1

NAME: SOLUTIONS

MARK: /40

1. Ajak, an archer, aims an arrow at a 25° angle at an apple across a field. Ajak fires the arrow from a height of 1.0 m with an initial speed of 33.0 ms^{-1} and hits the apple, which is 4.0 m above the ground. How far away (horizontal distance, X) is Ajak from the apple.

[6 marks]



$u = 33.0\ ms^{-1}$ @ $25°$

$u_V = u \sin 25°$

$= 13.9_5\ ms^{-1}$ (1)

$u_H = u \cos 25°\ (= V_H)$

$= 29.9_1\ ms^{-1}$ (1)

$S_V = +3\ m.$

$t_V = ?$

$a_V = -9.80\ ms^{-2}$

$S_V = u_V t_V + \frac{1}{2} a_V t_V^2$ (2)

$3 = 13.9 t_V - 4.9 t_V^2$

$4.9 t_V^2 - 13.9 t_V + 3 = 0$

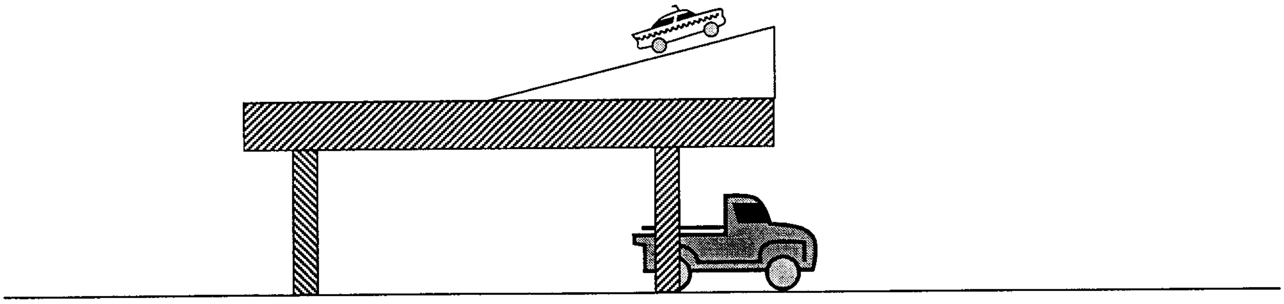
$t_V = 0.235\ s$ (way up) or $t_V = 2.60\ s$ (on way down)

$\therefore t_V = 2.60\ s = t_H$ (1)

$S_H = V_H t_H = 29.9 \times 2.6$

$S_H = 77.8\ m.$ (1)

2. Lee is attempting a clever trick. His toy car is travelling at 8.0 m s^{-1} on a small ramp inclined to the horizontal, which he placed on top of a table. Under the table on the floor, his toy truck is travelling at 4.5 m s^{-1}. At the position shown, the car is directly above the back of the truck. Lee is trying to get the toy car to land in the back of the toy truck. The top of the ramp is 65 cm above the back of the truck.



(a) At what angle should the ramp be inclined to the horizontal for the trick to work?

[3 marks]

$u_{CAR} = 8 \text{ ms}^{-1} @ \theta$

$u_{H,CAR} = u_{TRUCK} = 4.5 \text{ ms}^{-1}$ TO LAND ON TRUCK. (1)

$u_{H,CAR} = u_{CAR} \cos\theta$ (1)

$\cos\theta = \frac{4.5}{8.0} \approx 0.56$

$\theta = 56°$. (1)

(b) How far from the table do the toys travel before the car lands on the truck?
(ie: what horizontal distance is covered by the toys after the car leaves the ramp?)

[5 marks]

$u_{V,CAR} = u \sin\theta$
$= 8 \sin 56$ (1)
$= 6.6 \text{ ms}^{-1}$.

$a_V = -9.80 \text{ ms}^{-2}$

$S_V = -0.65 \text{ m}$ (1)

$s = ut + \frac{1}{2}at^2$

$4.9t^2 - 6.6t - 0.65 = 0$ (1)

$t = +1.44 \text{ s}$ (OR -ve)

$S_H = V_H t_H$ (1)
$= 4.5 \times 1.44$
$\approx 6.48 \text{ m}$
$\approx 6.5 \text{ m}$. (1)

(c) Calculate the speed and direction of the car when it lands on the back of the truck.

[4 marks]

$V_V = ?$

$u_V = 6.6\ ms^{-1}$

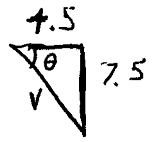
$a_V = -9.80\ ms^{-2}$

$s_V = -0.65\ m$

$V^2 = u^2 + 2as$

$V_V = -7.5\ ms^{-1}$ (i.e. down) (1)

$V_H = 4.5\ ms^{-1}$ (1)



$\tan\theta = \frac{7.5}{4.5}$

$\tan\theta = 1.66$ (1)

$\theta = 59^\circ$.

$V^2 = V_H^2 + V_V^2$

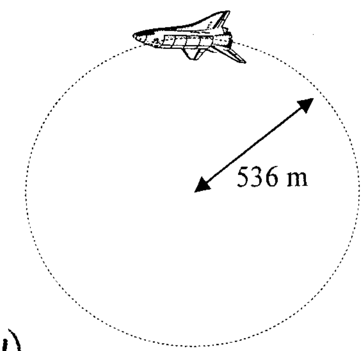
$V^2 = 76.5$

$V = 8.746\ ms^{-1}$ (1)

$\therefore\ V = 8.8\ ms^{-1}$ @ 59° BELOW HORIZONTAL.

3. Yenni flies a space shuttle from the surface of Mars into a vertical loop of radius 536 m. If her mass is 55 kg and her speed is 270 km h^{-1} at the top of the vertical loop, then what is Yenni's apparent weight at the top of this loop? (g at surface of Mars = 3.68 N kg^{-1})

[6 marks]



$m = 55\ kg$

$g_{MARS} = -3.68\ ms^{-2}$

$V = 270\ km\ h^{-1}$ (1)

$= \frac{270}{3.6} = 75\ ms^{-1}$

$r = 536\ m$

$F_c = F_N + F_g$ (1)

$F_N = F_c - F_g$

$= \frac{mv^2}{r} - mg$

(1) (1)

$= \frac{55 \times 75^2}{-536} - 55(-3.68)$

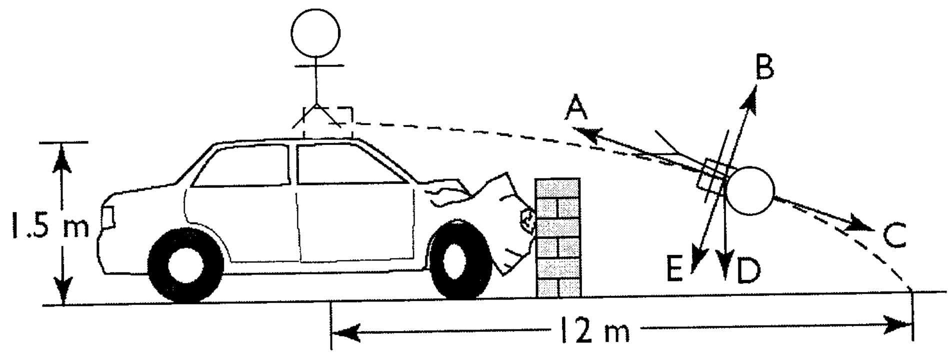
$= -577.2 + 202.4$ (1)

$= -375\ N.$

Her apparent weight is 375 N. (Seat is pushing her down.)

(1)

4. Thai was driving his car on a level road, in a 60 kmh^{-1} zone at a constant speed, when he accidentally hit a low rock wall. Fortunately, Thai was wearing his seatbelt and was unhurt in the accident. Unfortunately, Hamish was car-surfing at the time and, on impact, came off the roof, striking the ground 12 m in front of the point where he was standing on the car's roof.



a) Tari and her friend witnessed the accident, and Tari's friend yelled out: "Wow – it's amazing how Hamish was thrown forward like that!" Tari disagreed with what her friend said and offered a more correct physics-based explanation. What was Tari's explanation for Hamish's demise? [2 marks]

(1) - NEWTON'S 1ST LAW

(1) - HAMISH SIMPLY CONTINUED WITH HIS FORWARD VELOCITY WHILE THE CAR STOPPED - HE WAS NOT 'THROWN' FORWARD.

b) If the effects of air resistance *were* to be considered, which of the arrows A, B, C, D or E correctly indicates the *net force* on Hamish in the position shown? [2 marks]

(2) E. $F_g + F_{AIR\ RESISTANCE}$.

c) Miyako, the investigating police officer, was called to the scene and, after taking some measurements (as shown on the diagram above), and making certain assumptions, came up with an estimate of the speed of Thai's car when it collided with the wall. List her assumptions and determine the estimated speed. [5 marks]

(1) - HAMISH & CAR AT SAME SPEED
- IGNORED AIR RESISTANCE

$s_V = -1.5$ m
$a_V = -9.8\ ms^{-2}$
$u_V = 0\ ms^{-1}$
$t_V = ?$

$s = ut + \frac{1}{2}at^2$

$-1.5 = 0 - 4.9t^2$ (1)

$t_V = 0.55 s.$

$t_H = t_V = 0.55 s$ (1)

$s_H = 12 m$

$V_H = \frac{s_H}{t_H} = \frac{12}{0.55} = 21.7\ ms^{-1}$ (1)

ESTIMATED $V_{CAR} = 21.7 \times 3.6 = 78\ km\,h^{-1}$. (1)

d) Using your result from part (c) above, and assuming that Thai and Hamish have similar masses, estimate the impulse for each of them arising from the accident and compare the two results. [3 marks]

$m = 60\,kg$

$u = 21.7\,ms^{-1}$

$v = 0$

$I = ?$

$I = \Delta p$ (1)

$= mv - mu$

$= 0 - 60 \times 21.7$

$= -1300\ kg\,ms^{-1}$. (1)

I WILL BE SAME FOR EACH. (1)

e) Unlike Hamish, Thai was unhurt in this accident. Account for this by describing two major safety mechanisms that applied to Thai, but not to Hamish. Explain, with reference to your results from part (d) above, how these two mechanisms minimised any injury to Thai. [4 marks]

$\left.\begin{array}{l}\text{CRUMPLE ZONE}\\ \text{SEAT BELTS}\\ \text{AIR BAGS}\end{array}\right\}$ ANY TWO + BRIEF DESCRIPTION (2)

(1) $I = Ft$

I IS CONSTANT (FIXED AS ABOVE $-1300\ Ns$)

HOWEVER, FORCE APPLIED TO EACH PERSON DEPENDS ON TIME TO STOP (THE Δp TIME).

(1) WITH CRUMPLE ZONE, SEAT BELTS OR AIR BAGS THE TIME TO STOP IS INCREASED AND HENCE FORCE IS LESS.