ARANMORE CATHOLIC COLLEGE

PHYSICS 3A3B - 2010

MOTION TOPIC TEST 1

NAME: SOLUTIONS

MARK: /50

Instructions:

1. Answer all questions in the spaces provided on the test paper.
2. Show full working out to get full marks as shown in brackets after each question.
3. Answers should be in decimal form and show correct use of significant figures.
4. Graphic and scientific calculators as per Curriculum Council guidelines are permitted.
5. Answers **must** be in blue or black ink.

Questions:

1. a) Calculate the average force exerted by the seatbelts on Dan, the crash test dummy, of mass 65 kg in a car driven at 108 km h^{-1} into a solid concrete wall. The crumple zone of this car allows it to take 0.24 s to come to rest following the collision. [4 marks]

(1) $u = 108\ kh^{-1} = 30\ ms^{-1}$

$m = 65\ kg$

$v = 0\ ms^{-1}$

$t = 0.24\ s$

$\Delta p = mv - mu = 0 - 65 \times 30 = -1950\ Ns$ (1)

$I = Ft = \Delta p = -1950\ Ns$ (1)

$F = \frac{-1950}{0.24} = -8125\ N.$ (1)

(FORCE IS AGAINST DIRECTION OF MOTION)

b) Explain why seatbelts are designed to stretch a little during a collision rather than remaining rigid. [2 marks]

(1) – ALLOWS MORE TIME FOR PERSON TO COME TO REST

(1) – IF t INCREASES (AND I IS CONSTANT) THEN THE FORCE DECREASES. AVERAGE FORCE REDUCED FURTHER.

2. During the school athletics carnival Ceara is competing in the hammer throw. The 2.50 kg hammer swings in a horizontal path of radius 2.50 m at 1.20 revolutions per second. The chain remains horizontal at all times. [2 marks each]

a) Calculate the period of rotation of the hammer.

$$f = 1.2 \text{ Hz} \quad (1) \quad T = \frac{1}{f}$$

$$= \frac{1}{1.2}$$

$$= 0.833 \text{ s.} \quad (1)$$

b) Determine the orbital speed of the hammer.

$$V = \frac{2\pi r}{T} \quad (1)$$

$$= \frac{2\pi \cdot 2.50}{0.833}$$

$$= 18.8 \text{ ms}^{-1} \quad (1)$$

c) Find the centripetal acceleration of the hammer.

$$a_c = \frac{V^2}{r} = \frac{18.85^2}{2.5} = 142 \text{ ms}^{-2}. \quad (1)$$

(1)

d) Describe the motion of the hammer after Ceara releases it.

(1) – TANGENT TO CIRCULAR PATH OR STRAIGHT LINE IN DIRECTION IT WAS HEADING

(1) – PARABOLIC PATH TO GROUND OR DIAGRAM ()

3. Taylah drives her go-kart over a hump of radius 4.50 m, while maintaining a constant speed of 7.00 ms^{-1}. The combined mass is 220 kg.

[2 marks each]

a) What are the forces acting on Taylah at the top of the hump?

(1) – F_g, FORCE DUE TO GRAVITY – VERTICALLY DOWN (OR DIAGRAM)

(1) – F_N, NORMAL FORCE OF SEAT – ACTING UPWARDS

b) Find the resultant force acting on the go-kart and Taylah at the top of the hump.

(1)
$$F_g = mg = 220 \times (-9.80) = -2156 \text{ N}.$$
$$F_c = \frac{mv^2}{r} = \frac{220 \times 7^2}{-4.5} = -2396 \text{ N}.$$

$$F_N = F_c - F_g = -2396 - (-2156)$$
$$= -240 \text{ N}.$$ BUT SEAT CAN'T PUSH HER DOWN,

(1) HENCE $F_N = 0$ N AND TAYLAH 'TAKES OFF'.

c) At the conclusion of the ride, Taylah remarked that she felt 'lighter' as the go-kart moved over the top of the hump. Explain her observation.

(1) $F_N < F_g$ OVER HUMP

(1) AND APPARENT WT $= F_N$ $\therefore$ SHE 'FEELS' LIGHTER.

IN FACT, $F_N = 0$ N – APP. WTLESSNESS.

d) What is the maximum speed (in ms^{-1}) the go-kart could have at the top of the hump and still have its wheels in contact with the ground?

WHEN $F_N = 0$, OR $F_c = F_g$ (1)

$$\frac{mv^2}{r} = mg$$
$$v = \sqrt{gr}$$
$$= \sqrt{9.80 \times 4.50}$$
$$= 6.64 \text{ ms}^{-1}.$$ (1)

4. a) Why does a motorcyclist lean so far over when negotiating a curve on the race track? [3 marks]

(1) – F_c EQUALS THE FRICTIONAL FORCE AND $V \uparrow$ AS $F_c \uparrow$.

(1) – $F_c = \frac{F_W}{\tan\theta}$ WHERE θ IS ANGLE OF LEAN, SO $\theta \downarrow$ (IE. GREATER LEAN) PRODUCES GREATER F_c

(1) – HENCE CAN GO FASTER AROUND CURVE, WITHOUT FALLING OFF (PROVIDED TRACK HAS ENOUGH FRICTIONAL FORCE)

b) Is it possible for an object to be travelling at constant speed and yet still be accelerating? Explain your answer. [3 marks]

(1) YES:

(1) – AN OBJECT CAN MOVE IN A CIRCULAR PATH AT CONSTANT SPEED. HERE THE VELOCITY IS CONTINUALLY CHANGING DIRECTION, BUT NOT ITS MAGNITUDE.

(1) – THIS CHANGE IN VELOCITY IS BROUGHT ABOUT BY AN ACCELERATION DIRECTED TOWARDS THE CENTRE OF CIRCULAR PATH.

c) Under what conditions do you feel weightless when travelling over a circular hump in your car? [3 marks]

(1) – APPARENT WEIGHTLESSNESS OCCURS WHEN $F_N = 0$.

$F_c = F_N + F_g$ SO $F_c = F_g$ OR $a_c = g$. (1)

– SINCE $a_c = \frac{V^2}{r} = g$

$V = \sqrt{gr}$ (1)

– THIS OCCURS WHEN SPEED OVER HUMP IS $V = \sqrt{gr}$.

5. While competing at the Vines golf classic, Tito 'Tiger' Lozada hits a hole in one with a shot that reaches a maximum height of 125 m and has a range of 215 m. The ball lands directly in the hole without bouncing. (Neglect air resistance in your answers.)

a) How long did it take the ball to reach its maximum height? [2 marks]

$s_v = 125\ m$; $a_v = -9.80\ ms^{-2}$; $v_v = 0\ ms^{-1}$; $t_v = ?$

$s = vt - \frac{1}{2}at^2$ (1)

$125 = 0 - \frac{1}{2}(-9.80)t^2$

$t^2 = \frac{125}{4.9}$

$t_v = 5.05 s.$ (1)

b) What was the acceleration of the ball at its maximum height? [1 mark]

$a = a_v = g = -9.8\ ms^{-2}$ (i.e. DOWN) (1)

SINCE $a_H = 0$.

c) What was the initial speed of the ball as it left the tee (the launch point)? [3 marks]

$s_v = 125\ m$; $a_v = -9.80\ ms^{-1}$; $v_v = 0\ ms^{-1}$; $u_v = ?$

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

$u_v^2 = -2(-9.80).125$

$u_v = {}^{+}49.5\ ms^{-1}$. (1)

$s_H = 215\ m$; $t_H = 2t_v$; $t_H = 10.1 s$; $u_H = ?$

$u_H = \frac{s}{t}$

$= \frac{215}{10.1}$

$u_H = 21.3\ ms^{-1}$ (1)

$u = \sqrt{u_v^2 + u_H^2}$

$= 53.9\ ms^{-1}$. (1)

d) Calculate the speed of the ball 1.50 seconds after it was struck. [2 marks]

$u_H = 21.3\ ms^{-1}$; $u_v = 49.5\ ms^{-1}$; $t_v = 1.50 s$; $a_v = -9.80\ ms^{-2}$

$v_v = u_v + a_v t_v$

$= 49.5 - 9.8 \times 1.5$

$v_v = 34.8\ ms^{-1}$ (1)

$v_H = u_H = 21.3\ ms^{-1}$

$v = \sqrt{v_v^2 + v_H^2}$

$= 40.8\ ms^{-1}$. (1)

6. Hue is riding the roller coaster at Adventure World travelling on a horizontal section at 34.0 kmh^{-1} due south. If he enters a right-angled bend with a radius of 14.2 m and continues travelling at the same speed but in a westerly direction:

a) calculate the magnitude of the acceleration on Hue and the roller coaster as they move around the bend (in ms^{-2}). [3 marks]

$V = 34.0\ kh^{-1}$

(1) $= 9.44\ ms^{-1}$

$r = 14.2\ m$

$a_c = \frac{v^2}{r}$ (1)

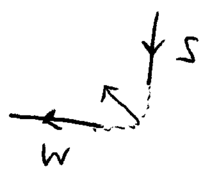
$= \frac{9.44^2}{14.2}$

$= 6.28\ ms^{-2}$ (1)

(TOWARDS CENTRE OF BEND)

b) In which direction was Hue's acceleration when he was halfway around the bend? [2 marks]

- TOWARDS CENTRE OF CIRCLE (1)



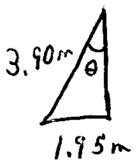
- NORTH-WEST (1)

OR BEARING OF 315°.

7. Dan is swinging around on a maypole chain that is 3.90 m long. He is travelling in a circle of radius 1.95 m and has a mass of 65.0 kg. Find his period of revolution.

[6 marks]

(1)



$$\sin\theta = \frac{1.95}{3.90} = 0.5$$

$$\theta = 30^\circ. \quad (1)$$

$$F_w = mg = 65.0 \times 9.80$$

$$= 637\ N. \quad (1)$$

$$\tan\theta = F_c / F_w$$

$$F_c = F_w \tan\theta$$

$$= 637 \times \tan 30^\circ$$

$$= 368\ N. \quad (1)$$

$$F_c = \frac{mv^2}{r} = \frac{m 4\pi^2 r}{T^2} \quad (1)$$

$$T^2 = \frac{4 m \pi^2 r}{F_c}$$

$$T = \sqrt{\frac{4 \times 65 \times \pi^2 \times 1.95}{368}}$$

$$= 3.69\ s. \quad (1)$$

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END OF TEST