Name: ______________________ /50

Physics 3AB Projectile and Circular Motion Test 2015

Instructions

1. Answer all questions in the spaces provided.
2. Give all numerical answers to three significant figures, except where you are required to estimate values where two significant figures will be appropriate.
3. Show all working – marks may be awarded for logical working even when an incorrect final answer is arrived at.
4. If you require extra working space, write "PTO" on the bottom of the page and continue working on the back of the page.

Questions

1. A cricketer plays a lofted on drive so that it leaves the bat very close to the ground upwards, at an angle of 38.0^0 to the horizontal with a total speed of 32.3m s^{-1}. Show, with appropriate diagrams and working, and ignoring air resistance, that the ball will clear the boundary rope 80.0m away (assuming there is no change in height over the playing area). (5 marks)

2. A 50.0g rubber stopper, tied to some thin fishing line, is being whirled in a vertical circle of radius 615mm. If a force of 5.00N will break the fishing line, at what minimum speed must the stopper be whirled at the bottom of the vertical circle to break the line? (3 marks)

3. The pilot of an aircraft points the nose directly west, but she experiences a crosswind **from** the south west blowing at 32.0m s^{-1}. If the aircraft's engines can normally produce a cruising speed of 88.0m s^{-1}, determine the **displacement** of the aircraft after 44.0 minutes. (6 marks)

4. A game of totem tennis involves a ball of mass 57.0g on a thin rope 1.10m long. At one point the rope makes an angle of 65.0^0 up from the vertical pole and the ball is travelling in a horizontal circle with constant speed.

a) Sketch a neat ~~vector~~ diagram showing the **real** forces acting on the ball. (2 marks)

free body

b) Determine the tension in the rope. (3 marks)

c) Determine the speed of the ball. (4 marks)

5. There is a hump in Southport St in West Leederville (speed limit 50km/h) with an approximate radius of 18m.
Show, with appropriate working, that the occupants of a car can become airborne without breaking the speed limit. (4 marks)

6. At Joondalup Country Club golf course there is a par 3 hole where the tee area is raised 16m above the fairway below, which then extends 175m to the flag/hole. The hole itself is in the centre of a circle of radius 15m. Stewart, a keen golfer, prefers to use a seven iron for a situation like this. Stewart's resulting shot, from right on the edge of the tee leaves the ground at an angle of 18.0^0 and with a speed of 179km/h.

a) Sketch a velocity vector diagram of the launch, showing the launch velocity and the values of its horizontal and initial vertical components. (4 marks)

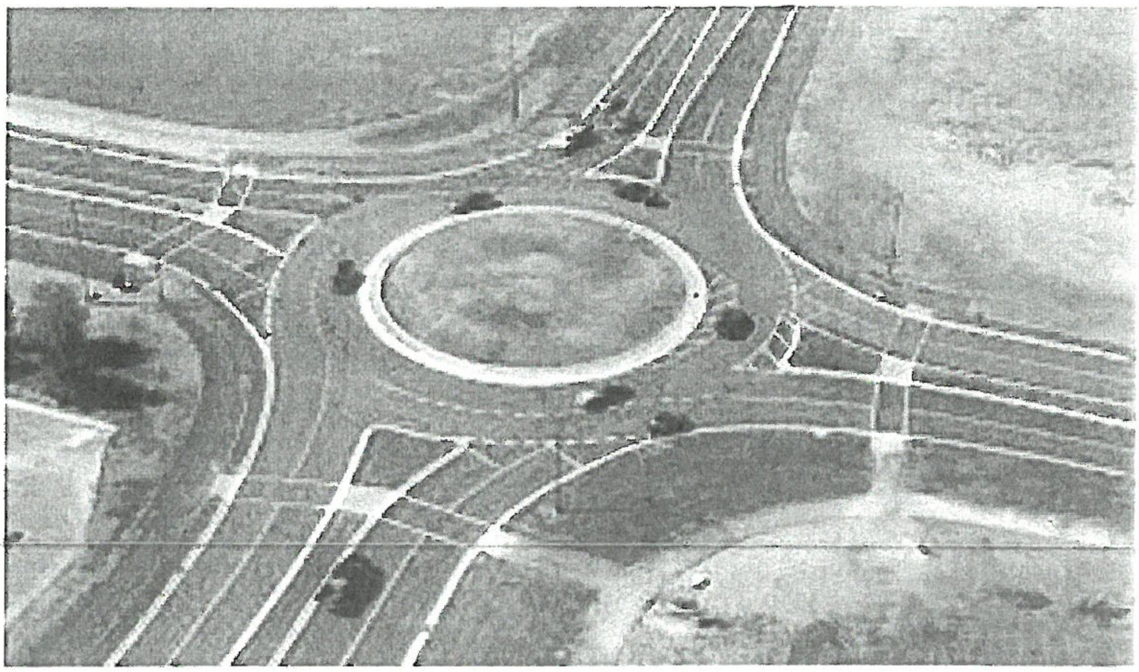
b) Determine the maximum height **above the fairway** that the ball attains. (3 marks)

c) Determine the total flight time of the ball. (4 marks)

d) Determine the location, **in relation to the flag/hole**, where the ball first strikes the ground. (2 marks)

e) Explain why the ball, in reality, will not travel the distance calculated in (d). (1 mark)

7. The photograph below shows a standard double lane roundabout on a Perth road.



By using estimations of appropriate values, determine:

a) the frictional force required by the average sedan to safely negotiate the roundabout at 50km/h. (4 marks)

b) the angle at which the road must be banked in order for vehicles to safely negotiate the roundabout, at 50km/h, without any need for friction. (3 marks)

c) Explain why banking the road makes travelling at higher speeds around corners safer. (2 marks)

Name: ____________________________ **/50**

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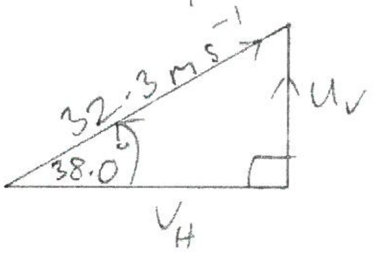
(i) Range $= V_H \times t_f$

(ii) For t_f : use $s_v = 0 = u_v t_f + \frac{1}{2} a t_f^2$ (1)



Let down be −ve.

ie $s_v = 0 = (32.3 \sin 38)\, t_f + (0.5 \times -4.9 \times t_f^2)$

ie $32.3 \sin 38^\circ t_f = 4.9 t_f^2$ (1)

ie $t_f = \dfrac{32.3 \sin 38^\circ}{4.9}$

$= 4.058\ldots$ s (1)

Now, RANGE $= V_H \times t_f$

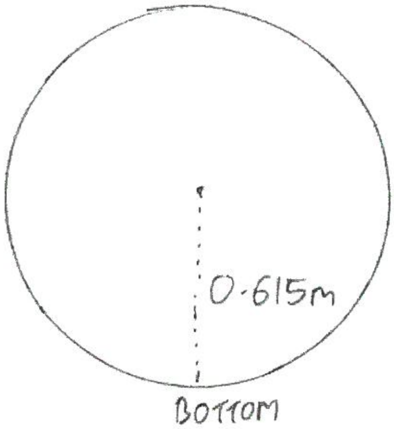
$= 32.3 \cos 38^\circ \times 4.058\ldots$

$= 103.29\ldots$ m (1)

ie $103 > 80$

$\therefore$ Ball clears rope. (1)

2. A 50.0g rubber stopper, tied to some thin fishing line, is being whirled in a vertical circle of radius 615mm. If a force of 5.00N will break the fishing line, at what minimum speed must the stopper be whirled at the bottom of the vertical circle to break the line? (3 marks)



At Bottom : $T = \frac{mv^2}{r} + mg$ (1)

ie $\frac{mv^2}{r} = T - mg = 5 - (0.05 \times 9.8)$

$= 4.51$ (1)

ie $v^2 = \frac{4.51 \times 0.615}{0.05}$

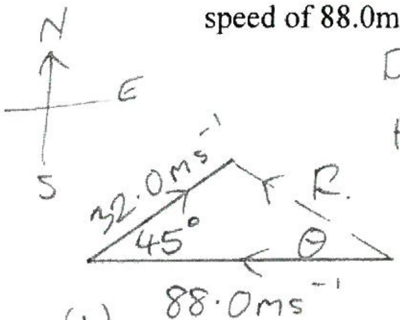
$v = \sqrt{55.47\ldots}$

$= 7.45 \text{ m s}^{-1}$ (1)

ie $F_c = 5N$

(1) only.

3. The pilot of an aircraft points the nose directly west, but she experiences a crosswind **from** the south west blowing at 32.0m s^{-1}. If the aircraft's engines can normally produce a cruising speed of 88.0m s^{-1}, determine the **displacement** of the aircraft after 44.0 minutes. (6 marks)



(1)

DISP. = VEL × TIME

FOR VEL : Use Cosine Rule

ie $R^2 = 32^2 + 88^2 - 2 \times 32 \times 88 \cos 45°$ (1)

$R = \sqrt{4785.5\ldots}$

$= 69.17\ldots \text{ m s}^{-1}$ (1)

FOR θ : $\frac{\sin\theta}{32} = \frac{\sin 45}{69.17\ldots}$ (1)

ie $\sin\theta = 0.327\ldots$ (ie $\frac{32 \times \sin 45}{69.17\ldots}$)

ie $\theta = 19.09\ldots°$

$\therefore B = 270 + 19.09\ldots$

$= 289°$ (1)

Now DISP = VEL × TIME

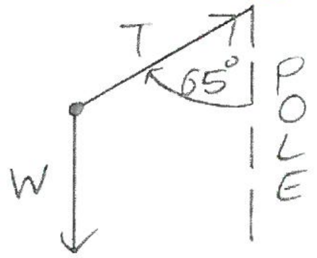
$= 69.17\ldots \times (44 \times 60)$

$= 1.83 \times 10^5 \text{ m}$ (1)

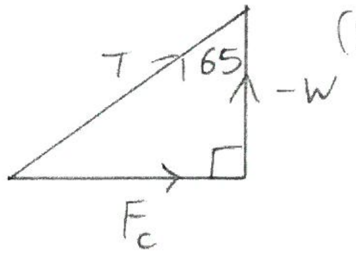
@ $289°$

4. A game of totem tennis involves a ball of mass 57.0g on a thin rope 1.10m long. At one point the rope makes an angle of 65.0^0 up from the vertical pole and the ball is travelling in a horizontal circle with constant speed.

a) Sketch a neat ~~vector~~ free body diagram showing the **real** forces acting on the ball. (2 marks)



b) Determine the tension in the rope. (3 marks)

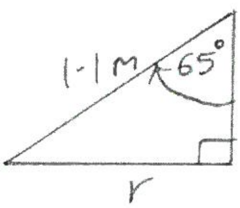


(1) $\cos 65 = \frac{W}{T}$

$\therefore T = \frac{W}{\cos 65} = \frac{0{\cdot}057 \times 9{\cdot}8}{\cos 65}$ (1)

$= 1{\cdot}32\,N$, up along rope. (1)

c) Determine the speed of the ball. (4 marks)



$\sin 65^\circ = \frac{r}{1{\cdot}1}$

$r = 1{\cdot}1 \times \sin 65$

$= 0{\cdot}996\ldots\,m$

(1)

For speed:

$\tan 65 = \frac{F_c}{W}$ (1)

$= \frac{v^2/r}{g}$

ie $\frac{v^2}{r} = g \tan 65$

ie $v = \sqrt{rg \tan 6{\cdot}5}$

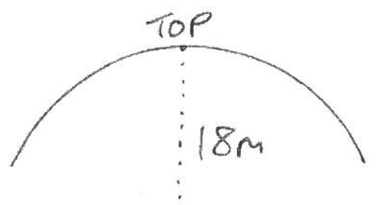
(1)

$= \sqrt{0{\cdot}996 \times 9{\cdot}8 \times \tan 65}$

$= \sqrt{20{\cdot}95}$

$= 4{\cdot}58\,ms^{-1}$ (1)

5. There is a hump in Southport St in West Leederville (speed limit 50km/h) with an approximate radius of 18m.
Show, with appropriate working, that the occupants of a car can become airborne without breaking the speed limit. (4 marks)



$N_{TOP} = \frac{mv^2}{r} - mg$ (1)

ie Any positive value for N means car will be airborne. (1)

50 km/h $= \frac{50}{3.6}$ ms^{-1} $= 13.8...$ ms^{-1}

ie if $\frac{v^2}{r} > g \Rightarrow$ Airborne

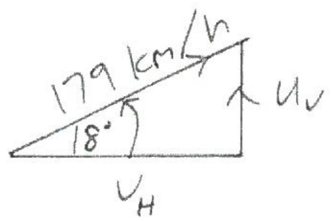
At speed limit : $\frac{v^2}{r} = \frac{13.8..^2}{18}$ (1)

$= 10.7...$ ms^{-2}

since $10.7 > 9.8$, car will be airbone at speed limit. (1)

6. At Joondalup Country Club golf course there is a par 3 hole where the tee area is raised 16m above the fairway below, which then extends 175m to the flag/hole. The hole itself is in the centre of a circle of radius 15m. Stewart, a keen golfer, prefers to use a seven iron for a situation like this. Stewart's resulting shot, from right on the edge of the tee leaves the ground at an angle of 18.0^0 and with a speed of 179km/h.

a) Sketch a velocity vector diagram of the launch, showing the launch velocity and the values of its horizontal and initial vertical components. (4 marks)

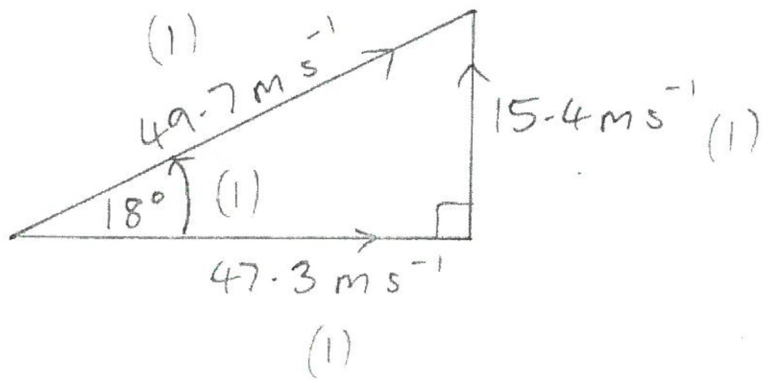


179 km/h $= \frac{179}{3.6} = 49.72...$ ms^{-1}

$u_V = 49.72 \times \sin 18^\circ = 15.365...$ ms^{-1}

$V_H = 49.72 \times \cos 18^\circ = 47.288...$ ms^{-1}

VECTOR DIAGRAM



b) Determine the maximum height **above the fairway** that the ball attains. (3 marks)

At max. ht. $v_v = 0$

$u_v = +15.365\ldots\ ms^{-1}$

$v_v = 0$ (1)

$a = -9.8\ ms^{-2}$

$s_v = ?$

Let up be +ve.

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

$s = \dfrac{v^2 - u^2}{2a}$

$= \dfrac{0 - 15.365^2}{-19.6}$ (1) $= 12.045$

$\therefore$ Max. ht. above fairway $= 16 + 12.0$ (1)

$= 28.0m$

c) Determine the total flight time of the ball. (4 marks)

$T_{TOTAL} = T_{UP} + T_{DOWN}$

$T_{UP}: t = \dfrac{v-u}{a} = \dfrac{0 - 15.3\ldots}{-9.8}$

$= 1.56\ldots\ s$

$T_{DOWN}: s = 28.045 = ut + \frac{1}{2}at^2$

ie $-28.045 = (0 \times t) + (0.5 \times -9.8 \times t^2)$

ie $t^2 = 28.045 \div 4.9$

$t_{DOWN} = \sqrt{5.723} = 2.39s$

$\therefore T_{TOTAL} = 1.56\ldots + 2.39\ldots$

$= 3.96s$

QUADRATIC METHOD

$s = -16 = (15.365t) + (0.5 \times -9.8 \times t^2)$

ie $4.9t^2 = 15.365t - 16 = 0$

$t = \dfrac{-(-15.365) \pm \sqrt{(15.3..)^2 - (4 \times 4.9 \times -16)}}{(2 \times 4.9)}$

$= \dfrac{15.365.. \pm \sqrt{549.6}}{9.8}$

$= (15.365 \pm 23.44\ldots) \div 9.8$

DISCOUNT -ve answer.

$\therefore t = 38.8\ldots \div 9.8$

$= 3.96\ s.$

d) Determine the location, **in relation to the flag/hole**, where the ball first strikes the ground. (2 marks)

$R_H = V_H \times t_f = 47.28\ldots \times 3.96\ldots$

$= 187.26m$ (1)

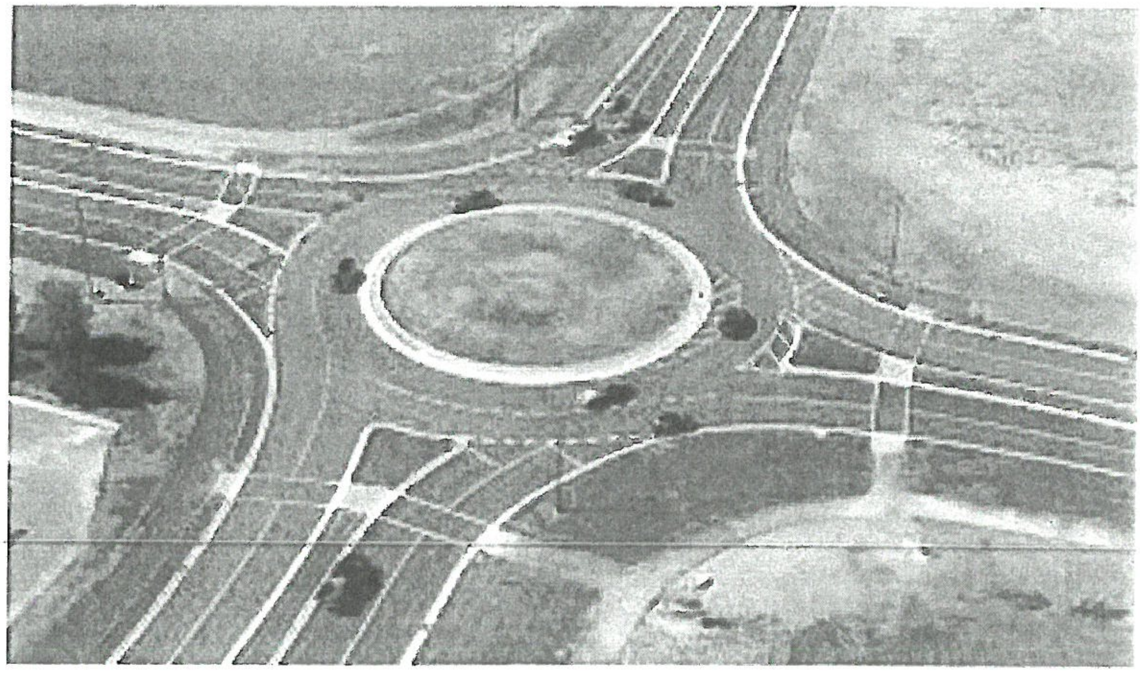
$\therefore$ Strikes the green 12.3m past the flag/hole (1)

(Assuming a straight hit)

e) Explain why the ball, in reality, will not travel the distance calculated in (d). (1 mark)

The ball experiences drag forces due to moving through which retard its motion (1)

7. The photograph below shows a standard double lane roundabout on a Perth road.



By using estimations of appropriate values, determine:

a) the frictional force required by the average sedan to safely negotiate the roundabout at 50km/h. (4 marks)

$r = 15 \rightarrow 20\,m$ (1)

$m \simeq 1000\,kg$ (1)

$v = 50 \div 3.6$

$= 13.8\,m\,s^{-1}$

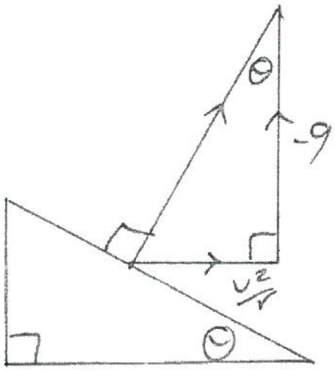
$F_f = F_c = \frac{mv^2}{r}$ (1)

$= \frac{1000 \times (13.8..)^2}{20}$

$= 9645\,N$ (1)

ie $\simeq 10\,000\,N$!

b) the angle at which the road must be banked in order for vehicles to safely negotiate the roundabout, at 50km/h, without any need for friction. (3 marks)



(1)

$\theta = TAN^{-1} \frac{\left(\frac{v^2}{r}\right)}{g}$ (1) $= TAN^{-1} \frac{\frac{(13.8..)^2}{20}}{9.8}$

$= TAN^{-1}\ 0.98...$

$= 44.5°$

$\simeq 45°$ (1)

c) Explain why banking the road makes travelling at higher speeds around corners safer. (2 marks)

The horizontal component of the normal (1) (or reaction) force from the banked road provides centripetal force so that vehicles don't just rely on (1) friction.