Physics ATAR - Year 12

Gravity and Motion
Test 1
2018

Name: SOLUTIONS	Mark: / 55 = % Teacher: CJO JRM

Time Allowed: 50 Minutes

Notes to Students:

1. You must include **all** working to be awarded full marks for a question.
2. Marks will be deducted for incorrect or absent units and answers stated to an incorrect number of significant figures.
3. **No** graphics calculators are permitted – scientific calculators only.

Question 1 **(5 marks)**

A projectile is fired horizontally from a height of 5.00 m with an initial velocity of 10.0 ms^{-1}. At the same time, a second projectile is fired horizontally from the same height with a velocity of 15.0 ms^{-1}. Calculate the distance the two projectiles are apart when they strike the ground. Ignore any effects of resistance.

Find t from sy

$s = ut + \frac{1}{2}at^2$ (½)

$= \frac{1}{2}at^2$

$t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2(-5)}{-9.8}}$ (½) $= 1.01s$ (1)

$s_1 = u_x.t$

$= 10.0 \times 1.01$ (1)

$= 10.1$ m

$s_2 = u_x.t$

$= 15.0 \times 1.01$ (1)

$= 15.2$ m

$\Delta s = s_2 - s_1$

$= 15.2 - 10.1$ (1)

$= 5.1$ m (1.d.p)

Question 2 **(3 marks)**

A person travelling over the crest of a hill travels in a vertical circular path. Describe what the person would feel as they are at the top of the curve and explain why.

- They would feel lighter / a decrease in apparent weight
- As they are undergoing centripetal acceleration the centripetal force is directed downwards
- The normal force reduces to produce a net force downwards, hence a reduction in apparent weight.

Question 3 **(8 marks)**

A steel ball of mass 2.00 kg is swinging in a circle of radius 0.500 m at a constant speed at the end of a string of length 1.00 m, as shown below.

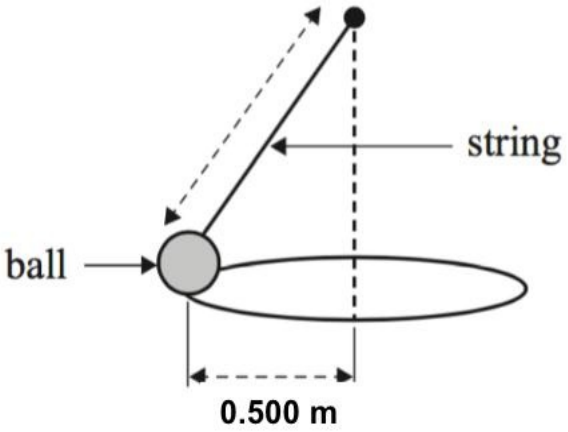


Figure 1.

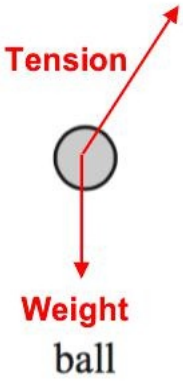


Figure 2.

(a) On Figure 2 above, draw all the forces that are acting on the ball.

(1 mark)

(b) Calculate the Tension in the string.

(4 marks)

$\theta = \cos^{-1}\frac{0.5}{1}$

$= 60.0$ (1)

$\sum F_Y = Ty + W = 0$ (1)

$= Tsin60 + W = 0$ (½)

$T = \frac{-mg}{sin60} = \frac{-2(-9.8)}{sin60} = 22.6N$ (½) (1)

(c) Show through calculation that the speed of the ball is 1.68 ms^{-1}

(3 marks)

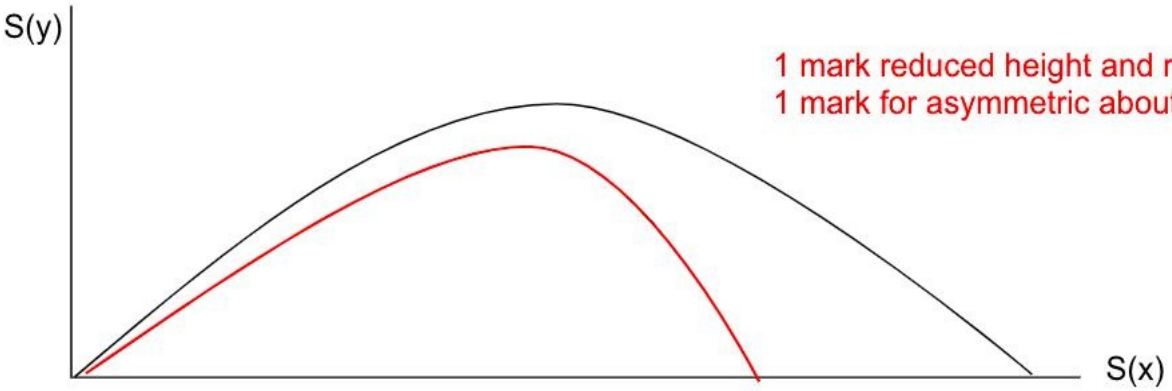
$\sum F_X = T_X = F_C = \frac{mv^2}{r}$ (1)

$\frac{mv^2}{r} = Tcos60$ (1)

$v = \sqrt{\frac{r.Tcos60}{m}} = \sqrt{\frac{0.5.22.6.cos60}{2}} = 1.68ms^{-1}$ (1)

Question 4 **(7 marks)**

A ball is projected from the ground at an angle of 30.0 ° to the horizontal and at a speed of 40.0 ms^{-1}, as shown below.



1 mark reduced height and range
1 mark for asymmetric about turning point

(a) Calculate the horizontal distance the ball travels before hitting the ground. (3 marks)

$s = ut + 1/2\ at^2$ ½

$0 = ut + ½\ at^2$ ½

$-ut = ½\ at^2$

$t = \frac{-2u}{a} = \frac{-2(40sin30)}{-9.8}$ 1

$= 4.08$ s

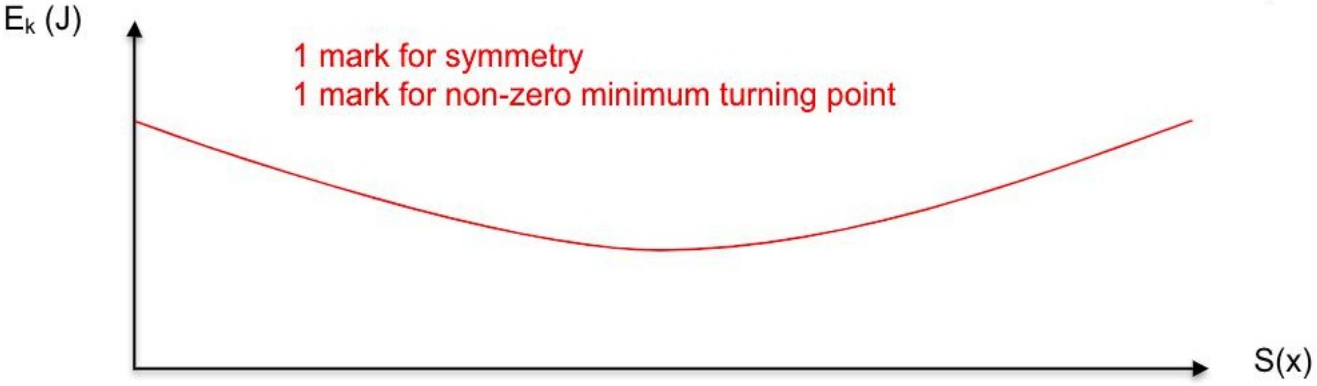
$s_x = u_x.t$

$= 40cos30.4.08$ 1

$= 141$ m

(b) On the diagram above, sketch the trajectory of the ball if it were to be influenced by the effects of air resistance. (2 marks)

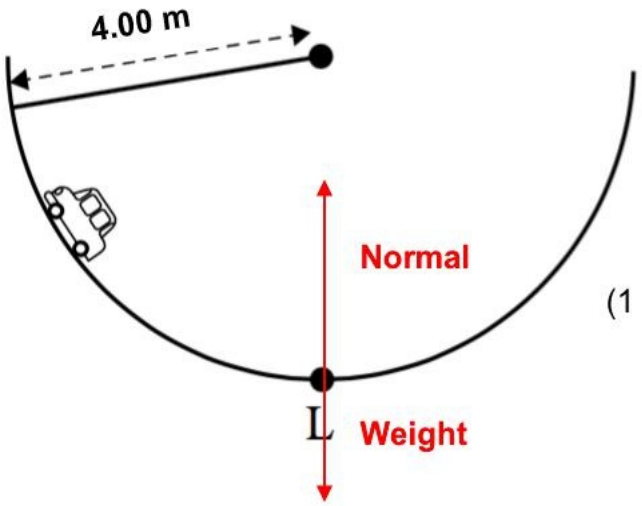
(c) On the axis below, sketch the kinetic energy of the ball as a function of horizontal distance without air resistance. (2 marks)



1 mark for symmetry
1 mark for non-zero minimum turning point

Question 5 **(9 marks)**

A model car of mass 1.20 kg is on a fixed track (that is not free to move or flex) that is part of a vertical circle of radius 4.00 m, as shown below. At the lowest point, L, the car is moving at 6.00 ms^{-1}. Ignore friction in this question.



(a) At the lowest point, L, draw the forces that would be acting on the car. (1 mark)

(b) Calculate the magnitude of the force exerted **by car on track** at its lowest point, L. (4 mark)

$\sum F_Y = F_C = \frac{mv^2}{r} = W + N$ (1)

(1)

$N = \frac{mv^2}{r} - W$

$= + \frac{1.2(6^2)}{4}$ - (1.2 x -9.8) (1)

=Force exerted by car is 22.6 N (1) (direction not required)

(c) Using energy considerations, calculate the maximum vertical height that the car rises to. (4 marks)

$\Sigma Ei = \Sigma Ef$ (1)

$\frac{1}{2} mv^2 = mgh_f$ (1)

$h_f = \frac{v^2}{2g} = \frac{6^2}{2(9.8)}$ (1)

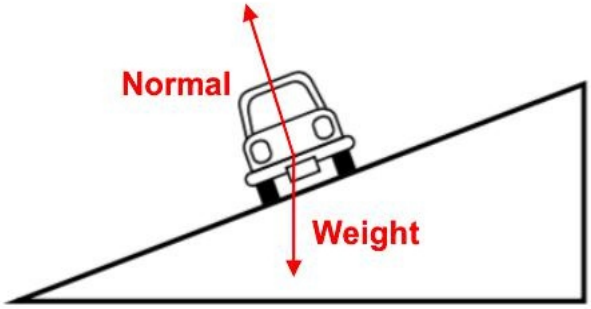
$= 1.84$ m (1)

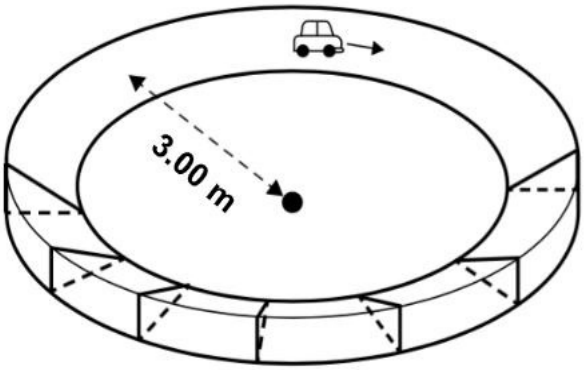
Question 6 **(8 marks)**

A model car of mass 2.00 kg is placed on a banked circular track. The car follows a path of radius 3.00 m. The motor maintains a constant speed of 2.00 ms^{-1}, as shown in the diagram. The angle of bank is such that there are no sideways frictional forces between the wheels and the track.

(a) On the diagram below, draw all the forces acting on the car using solid lines and label each force.

(1 mark)





(b) Calculate the required angle of bank of the track to maintain the car's circular path.

(4 marks)

$$\sum F_x = F_C = \frac{mv^2}{r} = N\sin\theta$$

$$N = \frac{mv^2}{r\sin\theta}$$ 1

$$\sum F_y = W + N\cos\theta = 0$$

$$N = \frac{-mg}{\cos\theta}$$ 1

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

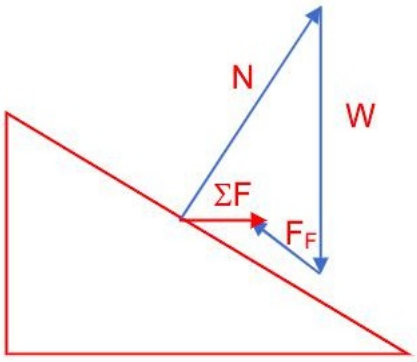
$$\frac{v^2}{rg} = \tan\theta$$ 1

$$\theta = \tan^{-1}\left(\frac{2^2}{3\times 9.8}\right) = 7.75°$$ 1

(c) If the car reduces its speed, explain, with the aid of a vector diagram, how friction between the wheels and the track would need to act in order to maintain its horizontal circular motion.

(3 marks)

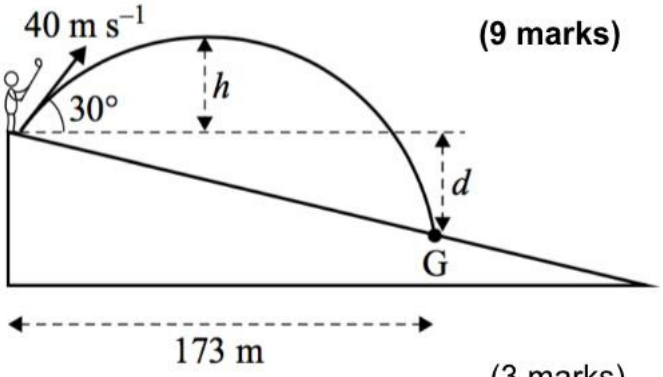
- If the car reduces its speed, normal force reduces
- In order to maintain a horizontal net force, F_F must act up the incline.



(1 mark for suitable diagram)

Question 7 **(9 marks)**

A golfer hits a ball on a part of a golf course that is sloping downwards away from him, as shown in the diagram. He strikes the ball at 30.0° above the horizontal with a speed of 40.0 ms^{-1}



(a) Ignoring air resistance, calculate the maximum height the ball raises above its original position. (3 marks)

$v^2 = u^2+2as$ 1

$s = \frac{-u^2}{2a}$ 1

$= \frac{-(40sin30)^2}{2(-9.8)}$ = 20.4 m 1

(b) The ball lands at a point at a horizontal distance of 173 m from the hitting-off point, as shown above. Calculate the vertical drop, *d*, from the hitting-off point to the landing point, G. (3 marks)

from x

$t = \frac{s_x}{ucos\theta} = \frac{173}{40cos30}$ 1

= 4.99 s

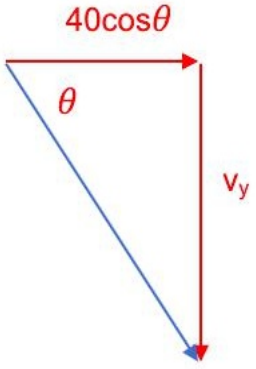
from y

$s = usin\theta t + ½ at^2$ 1

$= 40sin(30)(4.99) + (1/2)(-9.8)(4.99)^2$

= -22.2 m 1

(b) Calculate the velocity of the ball upon impact at point, G. (3 marks)



$v_y = u_y + at$

$= 40sin30 + (-9.8)(4.99)$ 1

$= -28.9\ ms^{-1}$

$v = \sqrt{(40cos\theta)^2 + 28.9^2}$

$= 45.1\ ms^{-1}$ ½

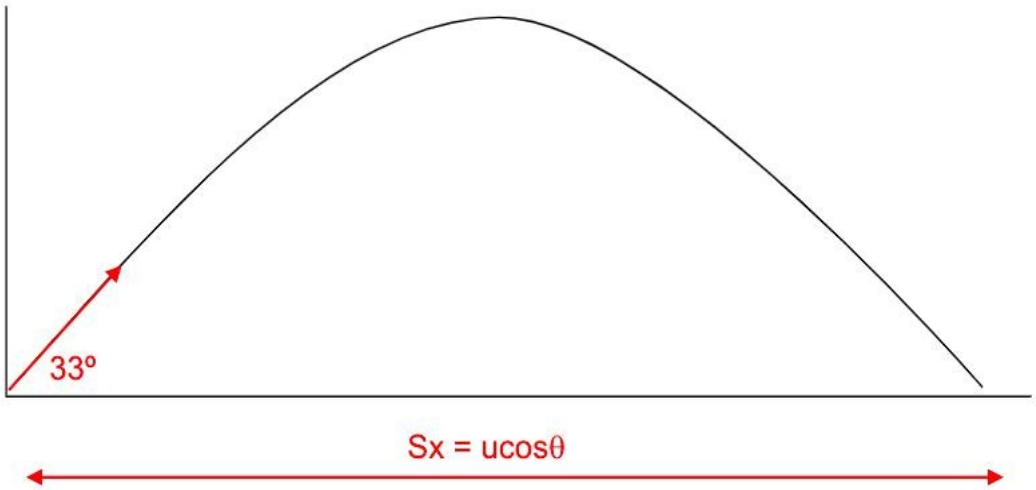
$\theta = tan^{-1}\left(\frac{28.9}{40cos30}\right)$

$= 39.9°$ ½

v = 45.1 ms-1 @ 39.9° below the horizontal 1

Question 8 **(6 marks)**

A javelin thrower is told that the angle to throw a javelin to achieve the greatest horizontal distance is 45.0° to the horizontal. She suspects that she can throw faster at lower angles and therefore achieve a greater distance. When throwing a javelin at 45.0°, she can achieve a horizontal distance of approximately 64.0 m. This is an initial velocity of 25.0 ms^{-1}. If she can throw fastest at an angle of 33.0°, what velocity is required at this angle to exceed a distance of 64.0 m?



From x

$t = \frac{s_x}{u\cos 33} = \frac{64}{u\cos 33} = \frac{76.3}{u}$ (1)

from y

$s = u_y t + \frac{1}{2} at^2$ (1)

$0 = u\sin 33 \times \frac{76.3}{u} + \frac{1}{2}(-9.8)\left(\frac{76.3}{u}\right)^2$ (1)

$0 = \frac{u\sin 33.76.3}{u} - (4.9)\left(\frac{76.3}{u}\right)^2$ (1)

$-41.6 = -\left(\frac{28534}{u}\right)^2$ (1)

$u = \sqrt{\frac{28534}{41.6}} = 26.2\ ms^{-1}$ (1)

END OF TEST