Physics 3AB - Year 12

Motion & Forces
Test One
2015

Mark: / 57

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Name: SOLUTIONS

Time Allowed: 50.0 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 **(3 marks)**

A car on the freeway is traveling at 108 kmh^{-1} North when the driver spots a hazard 78.0 m ahead. Calculate the acceleration needed to bring the car to a stop before the hazard.

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

$108 \div 3.6 = 30.0\ ms^{-1}$

$0 = 30^2 + (2 \times 78 \times a)$ 1

$a = -\frac{900}{156}$

$a = -5.77$

5.77 ms^{-2} South 1

Question 2 **(4 marks)**

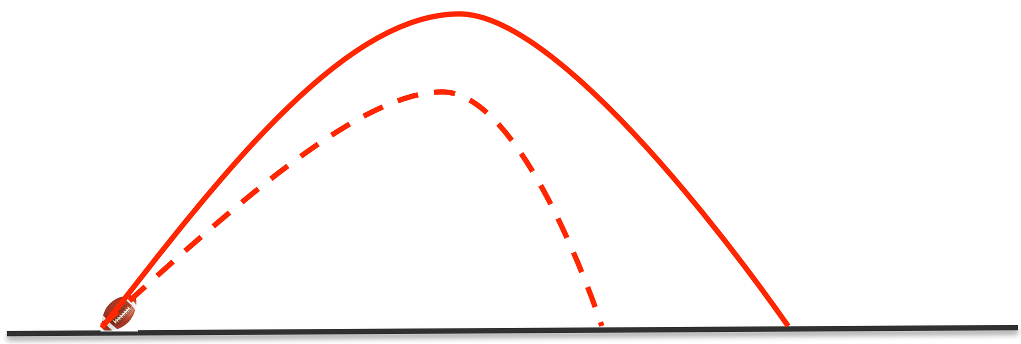
A football is kicked from a stationary position at an angle of 45° to the horizontal. On the diagram below draw the path of the football if:

(a) there is no air resistance (use a solid line ———————) (1 mark)

Line must be symmetrical

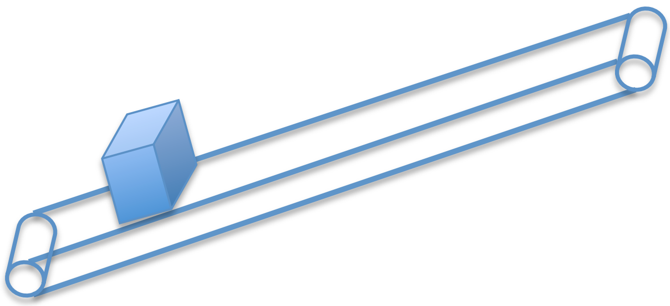
(b) there is air resistance (use a dashed line - - - - - - - -) (3 marks)

Line must have shorter range (1), lower height (1) and an asymmetric shape (1)



Question 3 **(6 marks)**

Conveyer belts are used in a factory to move boxes. One conveyer belt, which starts at ground level, has a length of 5.60 m and is angled at 32.0° to the horizontal. The friction force the belt can provide is 210 N.



(a) Calculate the maximum mass that can be moved up the conveyer belt, without slipping.

(3 marks)

$\Sigma F = ma$

$\Sigma F_{Horizontal} = F_f - mg\sin 32 = 0$ 1

$F_f = 9.8m\sin 32$ 1

$m = \dfrac{210}{9.8\sin 32}$

$m = 40.4$ kg 1

(b) The conveyer belt brings the box to a stop at the top of the ramp. Due to incorrect set up, the box falls off the top of the ramp after it has been brought to a stop. Using energy considerations, calculate the speed of the box when it reaches the ground.

(3 marks)

$\Sigma E_i + \Sigma E_f = 0$ 0.5

$E_p = mgh$

0.5

$E_k = \dfrac{1}{2}mv^2$

$mgh = \dfrac{1}{2}mv^2$

$v = \sqrt{2 \times 9.8 \times 5.6\sin 32}$ 1

v = 7.63 ms^{-1} 1

Question 4 (9 marks)

In a game of Mini Golf, a golfer attempts to make a hole in one when the hole is positioned on a platform that is 2.40 m above ground level. He strikes the ball so that it travels with a velocity of 12.6 ms^{-1} at an angle of 40.0° to the horizontal.

(a) If he is to make a hole in one, calculate how far from the hole he must stand.

(5 marks)

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

Vertical motion

$2.4 = (12.6 \sin 40)t - 4.9t^2$ 1

$4.9t^2 - (12.6 \sin 40)t + 2.4 = 0$

$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

t = 1.266 or 0.387 1

Select t = 1.266 s as this is the descent into the hole

Horizontal motion

$s = vt$ 1

$s = 12.6 \cos 40 \times 1.266$

s = 12.2 m 1

(b) Calculate the velocity of the ball as it reaches the hole.

(4 marks)

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

$v = \pm\sqrt{(12.6 \sin 40)^2 - (2 \times 9.8 \times 2.4)}$

$v = \pm 4.31$

$v_v = 4.31 \text{ ms}^{-1}$ 1

$v = \sqrt{4.31^2 + (12.6 \cos 40)^2}$ 0.5

v = 10.6

$\theta = \tan^{-1}\left(\frac{4.31}{12.6 \cos 40}\right) = 24.1°$ 0.5

v = 10.6 ms^{-1} at 24.1° below horizontal 1

Question 5 **(4 marks)**

When turning a corner in a car, a passenger feels like he is being pushed against the side of the vehicle. Making reference to Newton's Laws of Motion, explain why this is the case.

- Newton's 1st Law states that an object will continue in a state of constant, straight line motion unless acted on by a net external force.
- The passenger has mass, therefore he has inertia.
- As the car turns beneath him, he continues in straight line motion.
- The side of the car accelerates towards him, pushing on him but making him feel like he is being pushed onto it.

Question 6 **(5 marks)**

A cyclist is turning a corner on a flat road. He has a mass of 68.0 kg and his bike has a mass of 7.40 kg. The radius of the curve is 30.0 m and his speed is 28.5 kmh^{-1}.

(a) What provides the centripetal force in this situation?

(1 mark)

Friction

(b) Calculate the magnitude of this force.

(4 marks)

Total mass = 68 + 7.4 = 75.4 kg 0.5 $v = 28.5 \div 3.6 = 7.92\ ms^{-1}$ 0.5

$$F_c = \frac{mv^2}{r} \quad 1$$

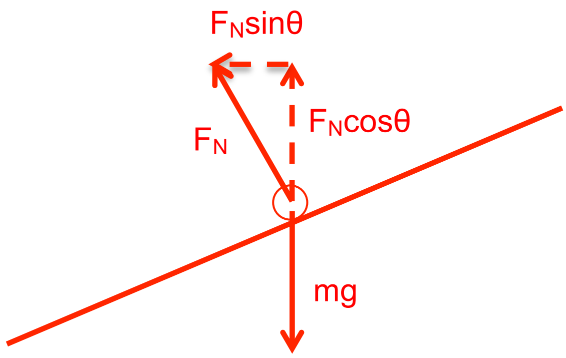
$$F_c = \frac{75.4 \times 7.92^2}{30} \quad 1$$

F_c = 158 N 1

Question 7 **(9 marks)**

(a) On a Formula 1 racetrack some corners are banked. With the aid of a labelled diagram, explain why cars are able to travel at a higher speed when taking these corners than they would on a flat road.

(4 marks)



1 mark for diagram (components of force not needed)

- The horizontal component ($F_N\sin\theta$) acts towards the centre of the circular path.
- This contributes to the centripetal force as well as friction, increasing the size of the centripetal force.
- As centripetal force is proportional to the magnitude of the velocity, ($F_C=mv^2/r$) as a larger centripetal force can be provided, the velocity can increase and a circular path maintained.

(b) A car of mass 700 kg is racing around a banked corner. He wants to be able to maintain a speed of 40.0 ms^{-1} as he takes the corner, which has a radius of 181 m. Calculate the minimum angle that the corner must be banked at in order for him to be able to do this.

(5 marks)

$$\Sigma F = ma$$

$$\Sigma F_H = F_N \sin\theta = \frac{mv^2}{r} \quad 1$$

$$\Sigma F_V = F_N \cos\theta = mg \quad 1$$

$$\frac{F_N \sin\theta}{F_N \cos\theta} = \frac{mv^2}{mgr} \qquad \tan\theta = \frac{v^2}{gr} \quad 1$$

$$\theta = \tan^{-1}\left(\frac{40^2}{9.8\times181}\right) \quad 1$$

θ = 42.1° 1

Question 8 **(8 marks)**

Some speed bumps are added to a road where the speed limit is 40 kmh^{-1}. A driver going over the speed bumps observes that he feels lighter as he drives over them.

(a) Explain why this is the case with the derivation of any appropriate formulae.

(5 marks)

- The driver perceives his sense of weight as the normal force of the seat pushing up on him.
- As he goes over the bump he is moving in a circular path, with weight contributing to the centripetal force.
- The normal force becomes less so he feels lighter.

$\Sigma F = ma = F_N - mg = -\frac{mv^2}{r}$ therefore $F_N = mg - \frac{mv^2}{r}$

1 1

(b) Calculate the minimum radius of the speed bump if a car of mass 1200 kg is able to drive along the road at the speed limit without losing contact with the road surface. Any formulae derived in part (a) do not need to be stated again.

(3 marks)

$F_N = 0$ 0.5

$F_c = mg$

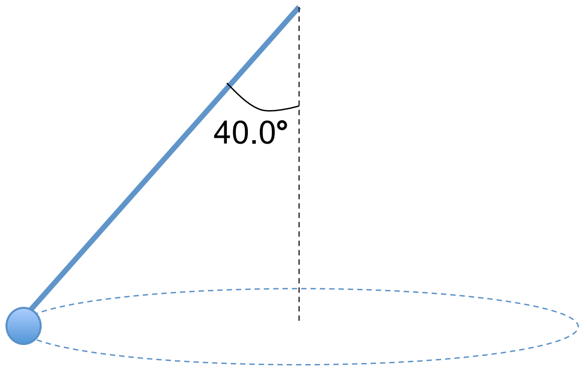
$\frac{mv^2}{r} = mg$ 0.5

$r = \frac{v^2}{g} = \frac{(40 \div 3.6)^2}{9.8}$ 1

r = 12.6 m 1

Question 9 **(9 marks)**

A poi performance involves swinging tethered masses through a variety of rhythmical and geometric patterns. One performer has poi equipment that is made of a 55.0 cm string with a 0.600 kg mass attached to the end. He begins to rotate it so that it follows the horizontal path shown below.



(a) If the speed of the poi is 7.00 ms^{-1}, calculate the magnitude of tension in the string.

(4 marks)

$\Sigma F = ma$ 1

T_H provides F_c

$F_c = \frac{mv^2}{r} = T \sin 40$ 1

r = 0.55 sin 40

$T \sin 40 = \frac{0.6 \times 7^2}{0.55 \sin 40}$ 1

T = 129 N 1

The poi is now swung in a vertical circle.

(b) At which point in the circle is the string most likely to break?

(1 mark)

At the bottom

(c) If the limit of tension that the string can withstand is 160 N, calculate the maximum speed with which the poi can be swung at this point in the circle.

(4 marks)

$\Sigma F = ma$

$\Sigma F = T - mg = F_c$ 1

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

$180 - (0.6 \times 9.8) = \frac{0.6v^2}{0.55}$ 1

v = 11.9 ms^{-1} 1

END OF TEST