Physics ATAR - Year 12

Gravity and Motion
Unit Test 1
2016

Name: SOLUTIONS

Mark: /53

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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 **(3 marks)**

A train starts to decelerate at a constant rate of 2.00 ms^{-2} when 132 m from Claremont Station. Calculate the speed of the train when the driver applied the brakes.

$a = -2.00\ ms^{-2}$ $s = 132\ m$ $v = 0.00\ ms^{-1}$ $u = ?$

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

$u = \sqrt{v^2 - 2as}$

$u = \sqrt{(0^2) - (2)(-2)(132)}$ (1)

$u = \sqrt{528}$

$u = 23.0\ ms^{-1}$ (1)

Question 2 **(4 marks)**

A plane flying horizontally at 300 kmh^{-1} drops a 50.0 kg box attached to a parachute that opens on leaving the plane. The designated release point is 535 m above the ground. Calculate the horizontal distance from the landing site that the pilot should release the box if the parachute and box descend at a constant 10.0 ms^{-1} on leaving the plane. Assume there is no wind acting at the time of the drop.

$v_H = 300\ kmh^{-1}$ $300/3.6 = 83.3\ ms^{-1}$ (1)

$s_V = 535\ m$

$v = \frac{s}{t}$ (1)

$v_V = \frac{s_V}{t}$

$t = \frac{535}{10} = 53.5\ s$ (1)

$v_H = \frac{s_H}{t}$

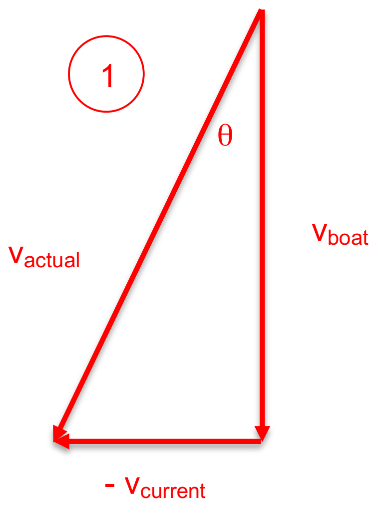
$s_H = (53.5)(83.3)$

$s_H = 4.46 \times 10^3\ m$ (1)

Question 3 **(4 marks)**

You are on a boat that can travel at a maximum average speed of 40.0 kmh^{-1} relative to the water. The boat is travelling across an open stretch of river from town A to town B, which is directly South of town A. There is a constant 5.00 kmh^{-1} current flowing during the crossing that is heading East.

Determine, with the aid of a diagram and calculation, the direction that the boat needs to be steered to arrive in Town B.



$V_{boat} - V_{current} = V_{actual}$

$\sin\theta = \frac{5}{40}$ (1)

$\theta = 7.18^\circ$ (1)

Direction = S7.18˚W (1)

Question 4 **(11 marks)**

In an experiment a student places a coin with a mass of 11.3 g face down at various distances from the centre axis of a horizontal rotating platform that has a radius of 20.0 cm. The platform is set to revolve at 30.0 rev/min.

(a) He observes that the coin remains in position when placed a maximum of 12.0 cm from the centre axis. Calculate the magnitude of the linear velocity of the coin in ms^{-1} at this point.

(3 marks)

$v = \frac{s}{t}$ $v = \frac{2\pi r}{T}$ or $v = 2\pi r f$ (1)

$v = (2\pi)(0.12)(0.5)$ (1)

$v = 0.377\ ms^{-1}$ (1)

(b) Determine the frictional force between the coin and the rotating platform when it is in this position.

(3 marks)

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

$$F_c = \frac{(11.3\times10^{-3})(0.377)^2}{0.12}$$ (1)

$F_C = 1.34 \times 10^{-2}$ N towards the centre axis (1)

(-0.5 mark if no direction)

(c) If the rate of revolution is increased would the position of the coin from the centre increase, decrease or stay the same? Explain your reasoning.

(5 marks)

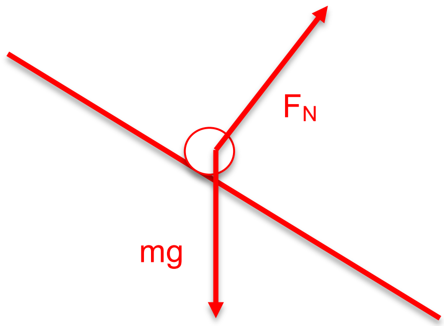
- The magnitude of the coin's velocity increases as rate of revolution has increased
- As $F_C = mv^2/r$, a greater amount of centripetal force will be required if the coin is to maintain its current radius.
- The friction between the coin and table is fixed and not sufficient to maintain the circular path.
- To keep the ratio of v^2 to r the same, to equal the friction between coin and table
- r, the distance of the coin from the centre, must increase.

Question 5 **(10 marks)**

In an Olympic cycling event a 65.0 kg rider sitting on his 6.80 kg bike rides around a tight bend at a radius of 15.9 m on a 32.0˚ banked section of the cycle track as shown in the photo.

(a) Next to the photo, draw a labelled diagram showing the forces acting on the rider and his bike as he rides around the banked bend.

(3 marks)



0.5 mark per arrow, 0.5 per label

1 mark for incline plane with F_N perpendicular

-1 if show centripetal force

(b) Calculate the magnitude of the rider and bike's velocity as he goes around the banked section of track.

(4 marks)

$\Sigma F = ma$ (0.5)

$F_N \sin\theta = F_c = \frac{mv^2}{r}$ (0.5)

$F_N \cos\theta = mg$ (0.5)

$$\frac{F_N \sin\theta}{F_N \cos\theta} = \frac{mv^2}{rmg}$$

$\tan\theta = \frac{v^2}{rg}$ (0.5)

$$v = \sqrt{rg\tan\theta}$$

$v = \sqrt{(15.9)(9.8)(\tan 32)}$ (1)

$v = 9.87\ ms^{-1}$ (1)

(c) A banked cycle track is designed to enable riders to negotiate the bend at speed without requiring the friction of the tyres to provide the centripetal force. Explain how this can occur.

(3 marks)

- As the cyclist rides along the banked curve the normal reaction force is perpendicular to the banked track.
- The horizontal component of the normal force ($F_N \sin\theta$) provides the centripetal force F_c
- There is no reliance on friction to maintain the circular pathway

Question 6 **(15 marks)**

A 68.0 kg stunt man is planning a sequence that will appear in a film. He will be riding a powerful 185 kg motor bike to complete a circular vertical loop that has a radius of 8.00 m.

(a) Calculate the minimum speed that he must be travelling at the top of the loop to complete it safely.

(3 marks)

$\Sigma F = ma$ (0.5)

$\Sigma F = F_c = F_N + mg$ (0.5)

$F_c = \frac{mv^2}{r}$ (0.5)

minimum speed means $F_N = 0$

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

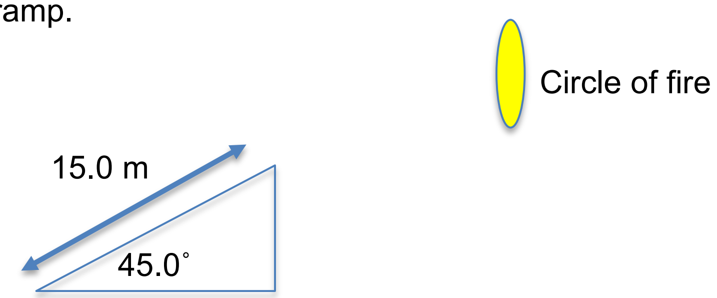
$v = \sqrt{rg}$

$v = \sqrt{(8)(9.8)}$

$v = 8.85 \text{ ms}^{-1}$ (1)

(b) In another part of the sequence he rides up a 15.0m long 45.0˚ ramp to jump through a 'circle of fire' and land on the ground. At the top of the ramp he is travelling at 10.0 ms^{-1}. Calculate the distance he lands from the ramp.

(6 marks)



$u_v = u \sin 45^\circ = 10 \sin 45 = 7.07$ ms^{-1} (0.5)

$u_h = u \cos 45^\circ = 10 \cos 45 = 7.07$ ms^{-1} (0.5)

assume up is +

$s_v = -(15.0 \sin 45)$ $\quad s_v = -10.6$ m (1)

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

Vertical: $-10.6 = (7.07)t + \frac{1}{2}(-9.8)t^2$

$4.9t^2 - 7.07t - 10.6 = 0$

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

$$t = \frac{7.07 \pm \sqrt{(-7.07)^2 - 4(4.9)(-10.6)}}{(2)(4.9)}$$ (1)

t = 2.36 s (1)

$s_h = u_h t$

$s_h = (7.07)(2.36)$

$s_h = 16.7$ m (1)

(c) Calculate the velocity of the bike as it just touches the ground.

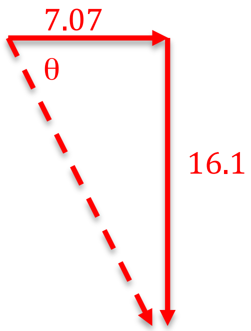
(6 marks)

horizontal: $v_H = 7.07\ ms^{-1}$

vertical: $v^2 = u^2 + 2as$ (1)

$v = \sqrt{(7.07)^2 + (2)(-9.8)(-10.6)}$

$v_v = 16.1\ ms^{-1}$ (1)



$v_{resultant} = \sqrt{(7.07)^2 + (16.1)^2}$ (1)

$v_{resultant} = 17.6\ ms^{-1}$

$\tan\theta = \frac{16.1}{7.07}$ (1)

$\theta = 66.3°$

$v = 17.6\ ms^{-1}$ 66.3° below horizontal

(1) (1)

Question 7 **(6 marks)**

A 1.00 m long piece of string is set up as a pendulum when a 0.500 kg mass is attached to the end of it. When pulled from one side the mass is raised 25.0 cm from it lowest position and released.

(a) Calculate the speed of the mass at its lowest position.

(3 marks)

$\Sigma E_i = \Sigma E_f$ (0.5)

$E_p = mgh$ $Ek = \frac{1}{2}mv^2$

(0.5) (0.5)

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

$v = \sqrt{(2)(0.25)(9.8)}$ (0.5)

$v = 2.21\ ms^{-1}$ (1)

(b) Calculate the tension in the string of the pendulum at its lowest point.

(3 marks)

$\Sigma F = ma$ (0.5)

$\Sigma F = T - mg = ma_c$ (0.5)

$F_c = \frac{mv^2}{r}$ (0.5)

$T = \frac{mv^2}{r} + mg$

$T = \frac{(0.5)(2.21)^2}{1} + (0.5)(9.8)$ (0.5)

T = 7.34 N upwards (1) (-0.5 mark if no direction)

END OF TEST