Year 12 Physics 2012

Motion and Forces Test 1

Name: Solutions

Mark:	/ 56
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Notes to Students:

- You must include **all** working to be awarded full marks for a question.
- Marks will be deducted for incorrect or absent units.
- Answers should be given to 3 significant figures.

1. Fred is driving his car around a bend when he notices that his small dog sitting on the parcel shelf is drifting towards the outside of the corner and the side of his car. Explain what is happening using the laws of motion.

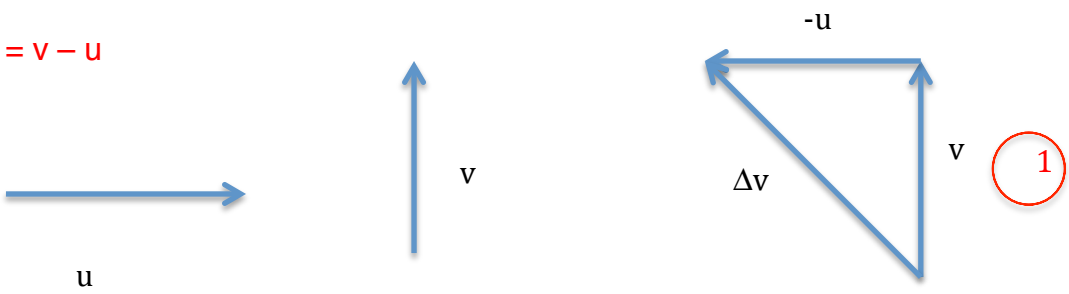
   - The dog has mass and therefore inertia.
   - Newton's 1st law states that an object will continue in uniform, straight line motion unless acted upon by a net external force.
   - The dog was travelling is a straight line and as the car turns the dog 'tries' to continue in a straight line as no external force is acting directly on the dog.
   - In effect the car is sliding across under the dog, which is trying to remain in its fixed position relative to the earth. This brings the side of the car closer to it.

   [4]

2. You are sitting on the latest thrill ride which fires you along a straight horizontal track until you reach a velocity of 30.0 ms^{-1}. The track then deviates at right angles to the left with no loss in speed. Include a diagram.

   What is your change in velocity?

   $\Delta v = v - u$



   $\Delta v^2 = 30^2 + 30^2$ (1)

   $\Delta v = 42.4\ ms^{-1}$ (1)

   45 degrees to the left of the final velocity (1)

   [4]

3. You have been asked to help coordinate a medieval reenactment involving a catapult attack on a castle. The catapult releases its projectile 8.00 m above ground at a velocity of 28.0 ms^{-1} 60.0° above the horizontal. The projectile is to hit the castle wall on its downward path 28.0 m above the ground.

a) Find the maximum height the projectile reaches in flight.

$a = -9.8\ ms^{-2}$
$u = 28 \sin 60$
$v = 0$
$s = ?$

$v^2 = u^2 + 2as$ (1)
$0 = (28 \sin 60)^2 + 2\ (-9.8)\ s$ (1)
$0 = 588 + (-19.6)\ s$
$s = 30.0$ m up from its start height or 38.0 m above ground level (1)

[3]

b) Calculate the time taken to hit the target.

using vertical only
$s = 20$ m
$u = 24{,}24 ms^{-1}$
$a = -9.8\ ms^{-2}$

$s = ut + ½\ at^2$ (1)
$20 = 24.24\ t + (-4.9)t^2$ (1)

solve using quadratic formula
$t = 1.04$ s or 3.90 s

time taken to hit target is 3.90 s (1)

[3]

c) What distance should the catapult be away from the castle wall when it fires.

time to hit target is 3.90 s
horizontal vel = 28 cos 60
$= 14\ ms^{-1}$

$s = v\ t$ (1)

$= 14\ (3.90\ s)$ (1)
$s = 54.6$ m from the castle wall. (1)

[3]

d) What is the velocity of the projectile when it makes contact with the castle wall?

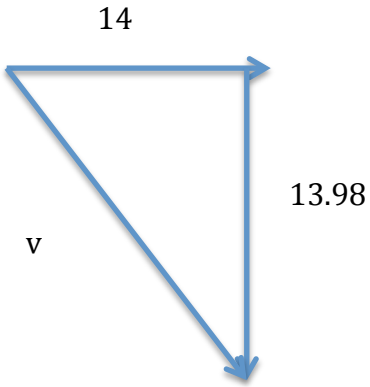
horizontal vel = 14ms^{-1}

vertical velocity on contact with wall

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

$v^2 = (24.24)^2 + 2\ (-9.8)\ 20$

$v = 13.98\ ms^{-1}$ (1)



$V^2 = 14^2 + 13.98^2$

$V = 19.8\ ms^{-1}$ at 44.9° below horizontal

(1) (1)

[4]

4. You begin your ride on a roller coaster by being pulled at a speed of 2.00 ms^{-1} to a height of 14.0 m. You are released as you go over the top.

a) Assuming no loss of energy with what speed would you crest the next hill which has a height of 9.00 m.

Conservation of energy

Initially $E_k + E_p = \text{final } E_k$ (1)

$½\ mu^2 + mgh = ½\ mv^2$ (1)

$½\ m\ (2)^2 + m\ (9.8)\ 5 = 1/2m\ v^2$ (1)

$2m + 49m = ½\ mv^2$

$v^2 = 102$

$v = 10.1\ ms^{-1}$ (1)

[4]

b) If this hill has a radius of 10.5 m what sensation with regard to your weight do you experience as you go over the crest? Verify your answer with a calculation.

$\Sigma F = ma$

$F_N - mg = -mv^2/r$

$F_N = mg - mv^2/r$ (1)

$F_c = mv^2/r = m(10.1)^2 / 10.5 = 9.71m$ N (1)

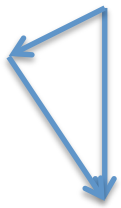
$F_{wt} = mg = 9.8m$ N (1)

- Since F_{wt} down exceeds reaction force of F_c then you will stay on the track,
- However you will feel much lighter, almost weightless as F_N = 0.09m N cf 9.8m N. (1)

[4]

5. A 200 kg pallet is being unloaded from a truck by sliding it down a ramp, which makes an angle of 25.0° to the horizontal with a frictional force of 10.0 N.

a) Once the pallet is on the ramp, what is its acceleration down the ramp?



200 x 9.8

$\sin 25 = x/1960$

$x = 1960 \sin 25$

$= 828$ N down the ramp

$\Sigma F = ma$ (1)

Nett force down the ramp is $828 - 10.0 = 818$ N (0.5)

$F = ma$

$a = F/m = 818/200$ (0.5)

$a = 4.09$ ms^{-2} (1)

[3]

b) If the pallet travels 3.20 m down the ramp what is its speed at the end of the ramp?

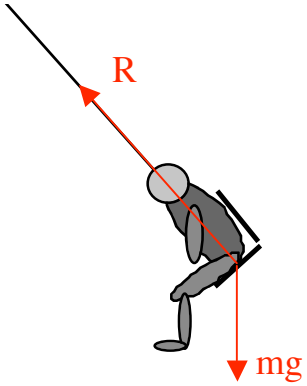
$v^2 = u^2 + 2as$ (1)

$v^2 = 2 \times 4.09 \times 3.2$ (1)

$v = 5.12\ ms^{-1}$ (1)

[3]

6. A swing at the Royal Show comprises a series of chairs attached by chains to a central rotating vertical pylon. As the pylon rotates the chairs swing out radially providing the thrill seeker sitting in the chair with their ride.



If the person in the chair has a mass of 70.0 kg and their radius of rotation is 8.50 m when the rider is rotating around the pylon at a frequency of 0.5 rev s^{-1},

a) calculate the speed of the person

r = 8.5m

t for 1 rev = 2 s

v = s/t (1)

Dist travelled per revolution = 3.14 x 17 = 53.38 m (1)

Speed then 26.7 ms^{-1} (1)

[3]

b) calculate the centripetal force

$F_c = mv^2/r$ 1

$= 70.0 \times (26.69)^2 / 8.5$ 1

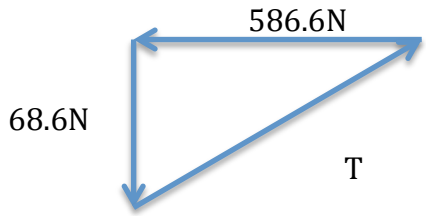
$= 5870$ N horizontally 1

[3]

c) calculate the tension in the chain.

vertical F = mg

$= 70.0 \times 9.8 = 686$ N vertically 1



$T^2 = (686)^2 + (5870)^2$ 1

$T = 5910$ N 1

Tan Q = 5870/686 = 83.3^o from the vertical 1

[4]

d) State what would happen to the radius of rotation if the rotational speed increased. Explain your reasoning.

- As the rotational speed increases the radius of rotation will increase. 1
- This means angle from vertical would also increase, so T sin θ increases 1

(As v increases, the amount of centripetal force required to maintain a circular path will increase as $F_c = mv^2/r$. To facilitate this a greater component of the tension is required in the horizontal plane, hence θ must increase so the Tsinθ component will increase. For θ to increase, r must increase.)

[2]

7. You are out fishing with a hand-line, where to cast your bait you swing the line in a vertical circle. If the radius of the circle is 1.50 m and the bait has a mass of 10.0g,

a) Calculate the tension in the line at the top of its rotation when you are maintaining the bait's speed at 9.00 ms^{-1}.

$\Sigma F = ma$
$-T - mg = -ma_c$ (1)

$T = mv^2/r - mg$
$= 0.01\ (9.0)^2\ /1.5 - 0.01\ (9.8)$ (1)
$= 0.54 - 0.098$
$= 0.442$ N (1)

[3]

b) What is its tension at the bottom of its rotation if you keep the speed constant?

$\Sigma F = ma$
$T - mg = ma_c$ (1)

$T = mv^2/r + mg$
$= 0.54 + 0.098$ (1)
$= 0.638$ N (1)

[3]

c) What is the baits minimum velocity at the top of its rotation to maintain its circular path if you stop providing the driving force?

At min vel at top $\therefore T = 0$

$mg = mv^2/r$ (1)

$v^2 = rg = 1.5 \times 9.8$ (1)

$v = 3.83\ ms^{-1}$ (1)

[3]