Physics ATAR - Year 11

Motion and Forces
Test 2
2019

Name: **SOLUTIONS**

Mark: / 57

= %

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 **(8 marks)**

Consider an object of mass “m” approaching an incline of angle “θ” at a speed “u”. While the object is on the incline, a constant frictional force “F_F” acts and the object travels a distance “s” along the incline before stopping and accelerating back down and leaving the incline with a speed “v”

(a) State and explain whether the object spends more time less time or equal time travelling up the incline compared to down the incline.

(3 marks)

Less time

As s is constant and $t = \frac{2s}{a}$, $t \propto \frac{1}{a}$

On the way up the incline, ΣF is greater in magnitude as F_F and F_g are in the same direction, hence a larger deceleration while traveling up, hence shorter time travelling up.

OR

On the way down the incline, ΣF is lesser in magnitude as F_F and F_g are in opposing direction, hence a smaller acceleration while traveling down, hence longer time travelling down.

(b) State and explain the required condition for the object to not return down the incline.

(2 marks)

F_F must be = F_g (Not greater…. No mark awarded for greater than)

Such that the object remains in equilibrium ΣF = 0

(c) Where the force of friction can be expressed as $F_F = \mu F_N = \mu mg\cos\theta$, show that the speed that the object leaves the incline can be expressed as:

$$v = \sqrt{2gs(sin\theta - \mu cos\theta)}$$

(3 marks)

$a = \frac{\Sigma F}{m}$ (1/2)

$= \frac{mgsin\theta - mg\mu cos\theta}{m}$ (1/2)

= $gsin\theta - \mu cos\theta$

= $g(sin\theta - \mu cos\theta)$ (1/2)

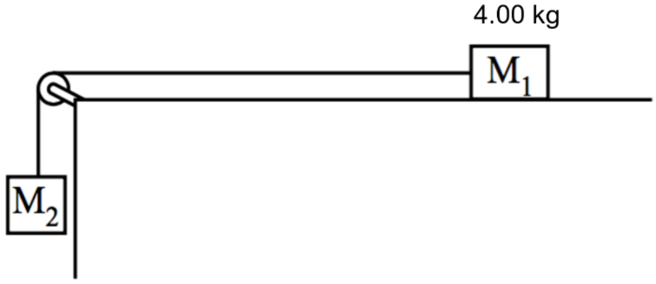
$v^2 = u^2 + 2as$ (1/2)

v = $\sqrt{2s(sin\theta - \mu cos\theta)s}$

= $\sqrt{2gs(sin\theta - \mu cos\theta)}$ (1)

Question 2 **(6 marks)**

Students set up an experiment as shown below.
M_1, of mass 4.00 kg, is connected by a light string to a hanging mass, M_2 of unknown mass. The system is initially at rest and is allowed to accelerate The acceleration is measured as 2.40 ms^{-2}.



(a) Ignoring the mass of the string and any friction, calculate the mass of M_2.

(3 marks)

$\Sigma F = m_2g = (m_1+m_2)a$ (1)

$9.8m_2 = (4 + m_2)\ 2.4$

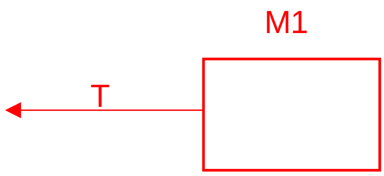
$9.8m_2 - 2.4m_2 = 9.6$ (1)

$7.4m_2 = 9.6$

$m_2 = 1.30$ kg (1)

(b) Calculate the magnitude of the tension in the string as the masses accelerate.

(3 marks)



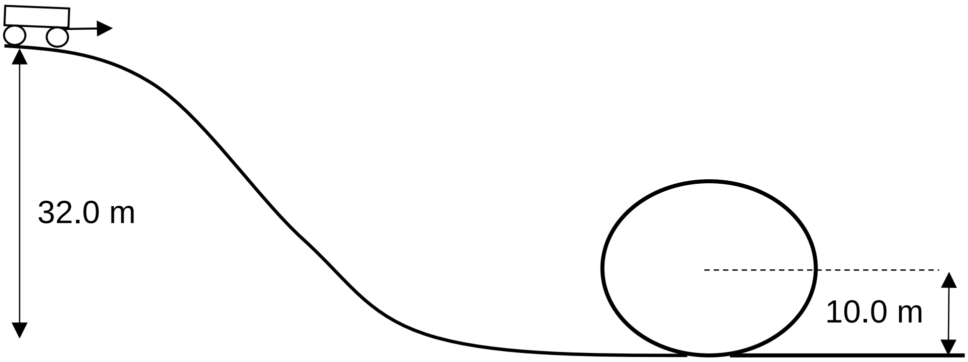
$\Sigma F_1 = m_1a_1 = T$ (1)

$4(2.4) = T$ (1)

$T = 9.60$ N (1)

Question 3 **(6 marks)**

A rollercoaster of mass 655 kg starts at rest and falls vertically 32.0 m before entering a "loop the loop" of radius 10.0 m. Engineers have determined that to safely complete the "loop the loop", the cart must have a speed of $v = \sqrt{rg}$ at the top of the loop. Ignore friction and air resistance in this question.



(a) Using concepts to conservation of energy, show via calculation whether the rollercoaster can safely complete the loop the loop.

(3 marks)

$E_i > E_f$ (1/2)

$mgh_i > \frac{1}{2}mv^2 + mgh_f$ (1/2)

$mgh_i > \frac{1}{2}mrg + mg(2r)$

$h_i > \frac{1}{2}r + 2r$ (1)

$h_i > 2.5\ r$

OR

$E_i > E_f$

$mgh_i > \frac{1}{2}mv^2 + mgh_f$

$655(9.8)(32) > \frac{1}{2}(655)(10 \times 9.8) + 655(9.8)(20)$

$205{,}408 > 44{,}835$

32 > 25 yes, rollercoaster can complete (1)

(b) Calculate the maximum speed of the roller coaster and state where this would likely occur.

(3 marks)

$E_T = E_{pi} = E_{kf} - E_{pf}$ (1/2)

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

$v = \sqrt{2gh}$

$= \sqrt{2 \times 9.8 \times 32}$ (1)

$= 25.0\ ms^{-1}$ (1)

Question 4 **(11 marks)**

A 0.170 kg cue ball travelling at a velocity of 2.50 ms^{-1} West collides with a stationary billiard ball (of equal mass). The billiard ball starts to move in the same direction as the cue ball at 1.80 ms^{-1}.

(a) Calculate the velocity of the cue ball after the collision.

(3 marks)

$\Sigma p_i = \Sigma p_f$ (1/2)

m1u1 + m2u2 = m1v1+ m2v2 (1/2)

+ ←→ -
west east

$0.17(+2.50) + 1.70(0) = (0.17)v_1 + 0.17(1.80)$

$v_1 = \dfrac{0.17(+2.50) – (0.17)(1.80)}{0.17}$ (1)

$= 0.700\ ms^{-1}$ West (1) (-1/2 mark if no direction)

(b) Calculate the impulse of the cue ball during the collision. (If you cannot complete (a), use a velocity of 0.900 ms^{-1} West.)

(3 marks)

$I = \Delta p = mv – mu$ (1)

$= 0.17(+0.7) – 0.17(+2.5)$ (1)

$= - 0.306\ kgms^{-1}$

$= 0.306\ kgms^{-1}$ East (1) (-1/2 mark if no direction)

(c) Determine, with a suitable calculation whether this collision is elastic or inelastic.

(3 marks)

Does $\Sigma E_i = \Sigma E_f$ (1/2)

$\frac{1}{2} m_1u_1^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$ (1/2)

$\frac{1}{2} (0.17)(2.5^2) = \frac{1}{2}(0.17)(0.7^2) + \frac{1}{2}(0.17)(1.8^2)$

$0.531\ J \neq 0.318\ J$ (1)

Hence inelastic. (1)

(d) State, making reference to a relevant equation, what additional information would be required to calculate the average force on the cue ball during the collision.

(2 marks)

$I = F\Delta t = \Delta p$ (1)

Δt is required (1)

Question 5 **(8 marks)**

A student wishes to know if he can generate more power by carrying more mass. He conducts an investigation during a science lesson by running as fast as he can up a 3.40 m flight of stairs and adds 5.00 kg to a weight-vest during each subsequent trial. His results are tabulated in the table shown.

Total Mass (kg)	Time (s)	Power (W)
52.0	2.80	619
57.0	3.15	603
62.0	3.60	574
67.0	3.92	570
72.0	4.50	533

(a) Derive an equation to determine the average power of the student in terms of mass, height, gravity and time.

(2 marks)

$P = \frac{E_p}{t}$ (1)

$= \frac{mgh}{t}$ (1)

(b) Complete the empty column in the table by calculating the average power during the student's stair climb.

(2 marks)

(c) State a suitable conclusion that can be drawn the student's results.

(1 mark)

Student generates less power as more mass is added

(d) Referring to the method that the student employed in his investigation, state one factor that could have affected the validity of his results, and hence, one modification that could improve the validity of this results.

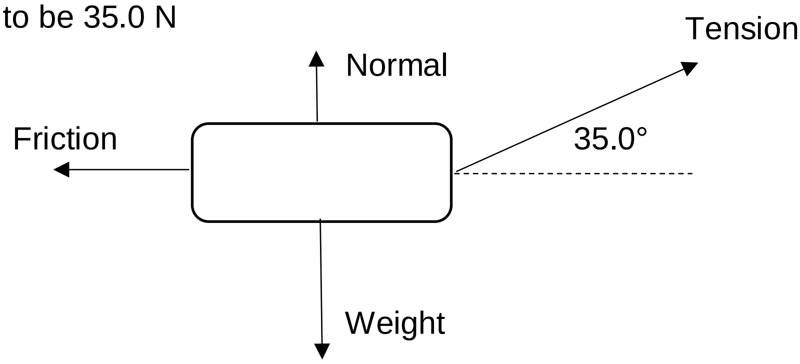
(3 marks)

- order of trials or duration of experiment
- fatigue / tiredness may have prevented valid results in later trial
- Reverse the order on a later day and average.

(Repeat trials mark not awarded)

Question 6 **(11 marks)**

The forces acting on a 15.0 kg sled being pulled horizontally at a constant speed by a student are shown below. The frictional force is measured to be 35.0 N



(a) Calculate the magnitude of the Tension force acting (3 marks)

$\Sigma F_x = 0 = T\cos\theta + F_F$ (1)

$T = \dfrac{-F_F}{\cos\theta}$

(1)

$T = \dfrac{35.0}{\cos 35}$

$= 42.7$ N (1)

(b) Explain, making reference to an appropriate physics concept, why the Normal force is smaller in magnitude than the weight force. (3 marks)

- $\Sigma F_y = 0 = F_N + T_y + W$
- Since, Ty and the normal force are opposing weight (acting upwards)
- Increasing Ty would decrease the normal force as weight is constant.

(c) Calculate the work done by the student if the sled is pulled a distance of 550 m. (3 marks)

$W = F_x \times s$ (1)

$= 35.0 \times 550$ (1)

$= 19{,}300$ J (1)

(d) Explain, with a suitable argument or calculation, the work done on the sled. (2 marks)

Zero.

As $W = \Delta E = E_f - E_i$ and cart is travelling at constant speed, there is no transfer of energy to the sled.

Question 7 **(4 marks)**

A 65.0 kg student stands on a set of bathroom scales on the floor of an elevator. If the elevator is moving downwards but slowing down at a rate of 1.50 ms^{-2}, calculate the apparent weight and hence the "mass" that would be shown on the scales as it is slowing down.

$a = +1.50\ ms^{-2}$

\+ $\Sigma F = ma = W + F_N$ (1)

$65(+1.5) = 65(-9.8) + F_N$ (1)

$F_N = 735$ N upwards (1)

\- $\div 9.8$

$= 75.0$ kg (1)

Question 8 **(3 marks)**

Passengers standing in a bus appear to lurch forward when the bus suddenly brakes. Explain, making reference to an appropriate law of motion, why they appear to lurch forward.

- Passengers in the bus have mass hence inertia.
- Newton's 1st law states that an object in motion will remain in motion unless acted upon by an external unbalanced force.
- When the bus brakes, there is no external unbalanced force acting on the passengers, hence they continue to travel in straight line motion.

END OF TEST