Christ Church Grammar School

Science Department
Year 12 2021

ATAR PHYSICS
UNIT 3: MOTION AND FORCES
TEST 1 2021

Student Name:

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Teacher: CJO JRM PCW
(Please circle)

Time allowed for this paper
Working time for paper: 50 minutes.

Instructions to candidates:

- You must include **all** working to be awarded full marks for a question. Answers should be expressed to 3 significant figures unless otherwise indicated.
- Marks may be deducted if diagrams are not drawn neatly with a ruler and to scale (if specified).
- Marks will be deducted for incorrect or absent units.
- **No** graphics calculators are permitted – scientific calculators only.

Mark:	/ 52
=	%

Question 1 **(6 marks)**

A boy and his younger brother are standing 40.0 m away from each other on level ground. The boy holds his paintball gun 1.40 m above the ground and aims it at an angle to hit his brother's chest, 1.00 m above the ground. When he pulls the trigger, the paintball takes 0.640 s to reach his brother.

(a) Calculate the horizontal component of the paintball's velocity.

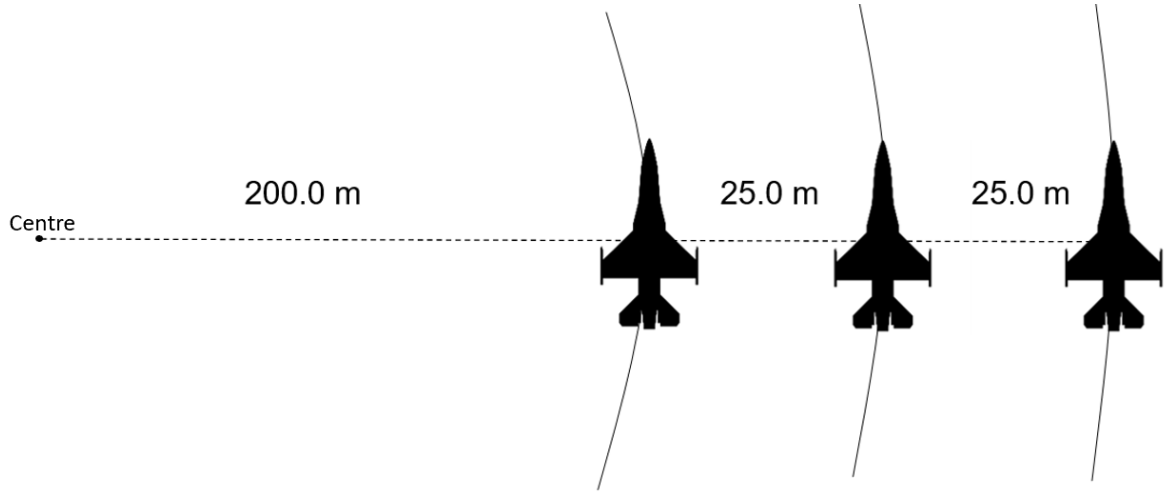
(2 marks)

(b) Calculate the angle of the gun that would strike his brother directly on the chest.
(If you could not solve part (a) assume a horizontal velocity to of 50.0 m s^{-1})

(4 marks)

Question 2 **(6 marks)**

Three fighter jets are performing an aeronautics display by flying in formation; completing a horizontal circular path so that they stay in line with each other. The fighter jets are 25.0 m apart and the inside fighter jet is travelling at 528 km h^{-1}. Top down diagram shown below (not to scale).



(a) Calculate the magnitude of the velocity of the middle pilot.

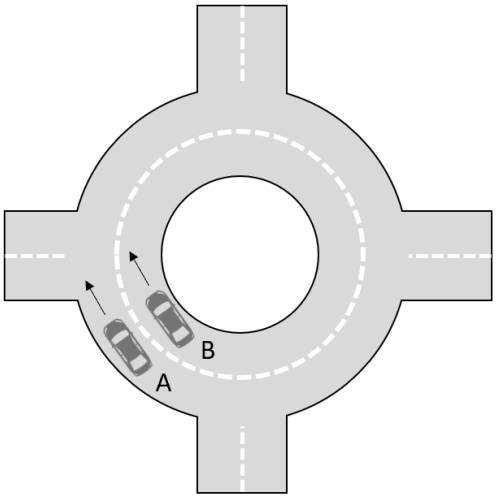
(3 marks)

(b) Calculate the ratio of the lateral acceleration experienced by the inside pilot compared to the outside pilot.

(3 marks)

Question 3 **(10 marks)**

In constructing roundabouts, the maximum safe horizontal force (supplied by friction) allowed by the Department of Mains Roads is 0.750 times the weight of the car travelling around it. Consider a proposed dual lane roundabout below.



(a) Calculate the minimum radius of curvature for the dual lane roundabout if the speed limit is 40.0 km h^{-1}.

(4 marks)

(b) Comment on the speeds that the cars could safely travel at in the outer lane compared to the inner lane.

(3 marks)

(c) A 1250 kg super car can create 35,100 N of lateral force due to friction. Calculate the maximum speed (expressed in km h^{-1}) it could theoretically travel around the inner lane. (If you could not complete part (a), use r = 18.0 m)

(3 marks)

Question 4 **(4 marks)**

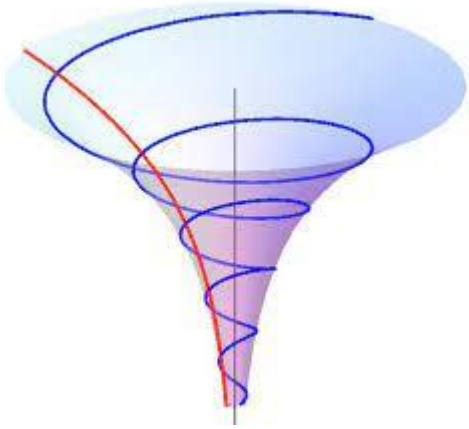
An idealised projectile that is launched and lands at the same level will spend the same amount of time travelling up and down, and its trajectory will form a perfectly parabolic shape. Describe and briefly explain the differences in trajectory of a real projectile, subject to the effects of air resistance.

You must address:

- Time of flight up and down
- Horizontal range
- Shape of the trajectory

Question 5 **(8 marks)**

Charities often use a spiral wishing well to ask for coin donations. When a person drops a coin into the slot, the coin will roll around the well in a spiral fashion, gradually reducing its radius until it falls into the central hole. Its trajectory is similar to that shown in the diagram.



(a) Draw a side view free body diagram of the coin at any point during its spiralling motion, assuming the well is frictionless.
(2 marks)

(b) With reference to an equation of circular motion and the free body diagram above, explain why the radius of curvature of the coin decreases over time. (You may ignore the vertical component of its trajectory for the purposes of explanation)
(2 marks)

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(c) Explain your answer to part (b) with reference to Newton's 1st and 2nd Law.
(4 marks)

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Question 6 **(6 marks)**

The Gravitron, pictured below, is a popular fairground ride in which passengers are spun around horizontally in a cylinder shaped ride and feel as though they are "pushed" into the vertical walls of the spinning "room".

The ride spins at 30.0 rpm and the coefficient of friction of people on the walls is $\mu = 0.240$, where frictional force $F_f = \mu N$.

(a) Calculate the tangential speed at the walls in terms of 'r' (in m s^{-1})

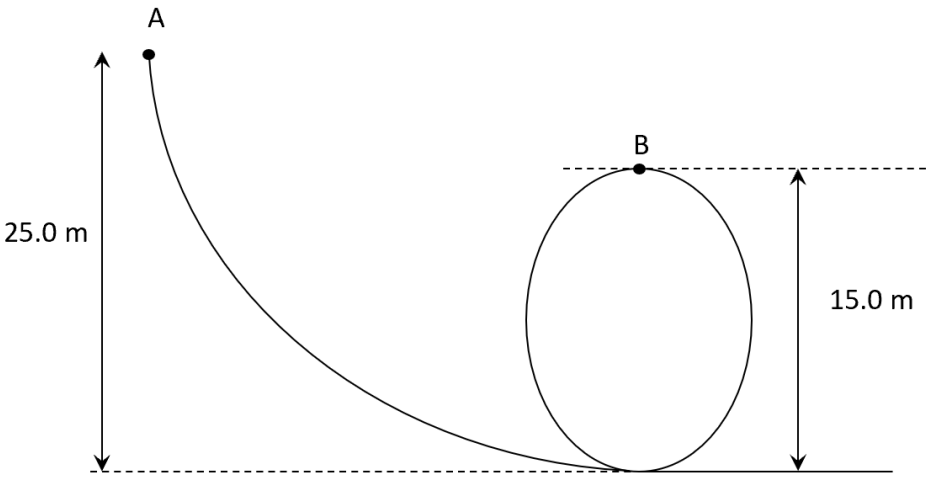
(2 marks)

(b) Calculate the minimum radius of the spinning 'room' to ensure there is no downwards slippage of the passengers during the ride, allowing them to "defy gravity".

(4 marks)

Question 7 **(6 marks)**

A passenger of mass 90.0 kg is sitting in a rollercoaster cart which is released from rest from a ramp at Point A at a height of 25.0 m above ground level. The cart then completes a vertical loop. Assume the rollercoaster is subject to the forces of gravity only and friction is negligible.



(a) Calculate the speed of the cart at the top of the loop, point B, 15.0 m above the ground.

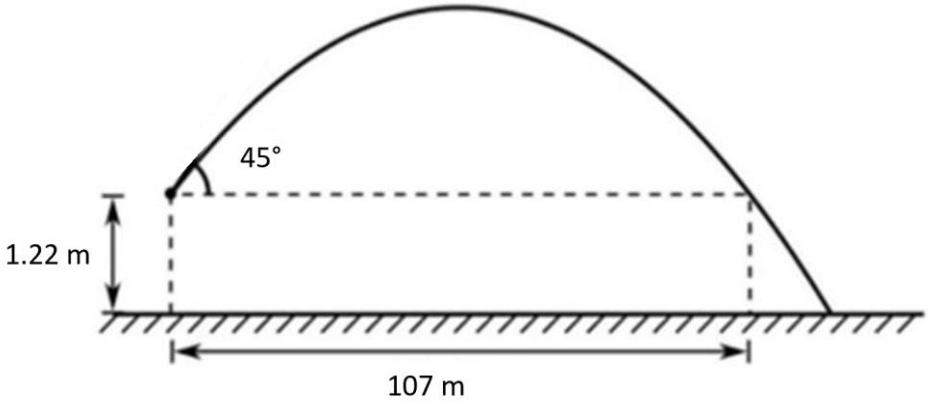
(3 marks)

(b) Calculate the apparent mass of the passenger at Point B. (If you could not answer part (a) use $v = 13.5 \text{ m s}^{-1}$)

(3 marks)

Question 8 **(6 marks)**

A batsman hits a ball at a height of 1.22 m above the ground so that the ball leaves the bat an angle of 45.0° with the horizontal. A 7.31 m high wall is situated at a distance of 97.5 m from the position of the batsman. If there were no wall, then the ball would be 107 m away when it is again at a height of 1.22 m. Prove through calculation whether the ball will clear the wall.



END OF TEST