

91171



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2

SUPERVISOR'S USE ONLY

Level 2 Physics, 2016

91171 Demonstrate understanding of mechanics

9.30 a.m. Tuesday 15 November 2016
Credits: Six

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of mechanics.	Demonstrate in-depth understanding of mechanics.	Demonstrate comprehensive understanding of mechanics.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Make sure that you have Resource Sheet L2–PHYSR.

In your answers use clear numerical working, words and/or diagrams as required.

Numerical answers should be given with an appropriate SI unit.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

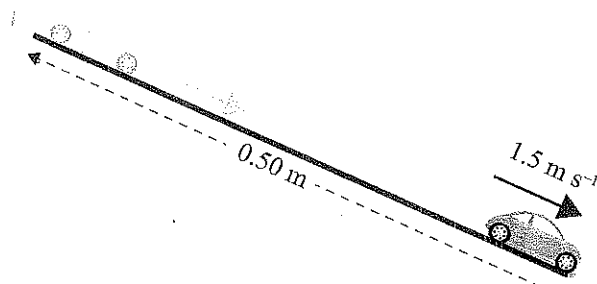
Check that this booklet has pages 2–8 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Merit
TOTAL **16**

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QUESTION ONE: MOTION

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Sarah releases a red car, $v_i = 0$, from rest, down a slope of length $d = 0.50$ m.

The red car accelerates steadily and reaches a speed of 1.5 m s^{-1} when it gets to the bottom of the slope.

$$v_f = 1.5$$

- (a) Calculate the acceleration of the red car as it moves down the slope.

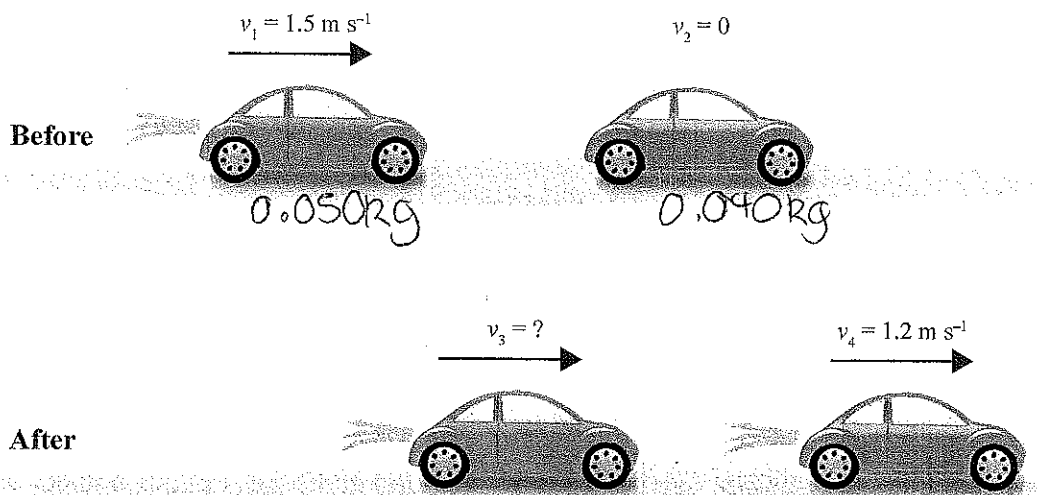
$$v = \frac{\Delta d}{\Delta t}$$

$$a = \frac{\Delta v}{\Delta t}$$

$$t = \frac{\Delta d}{v} = \frac{0.5}{1.5} = 0.333 \text{ s}$$

$$a = \frac{1.5}{0.33} = 4.5 \text{ m s}^{-2}$$

At the bottom of the slope, the track is flat. The red car, moving with the speed of 1.5 m s^{-1} , collides with a stationary blue car. The mass of the red car is 0.050 kg , and the mass of the blue car is 0.040 kg .



- (b) If the velocity of the blue car after the collision is 1.2 m s^{-1} , calculate the velocity of the red car after the collision.

$$p_{\text{initial}} = p_{\text{final}}$$

$$(0.050 \times 1.5) + (0.040 \times 0) = (0.050 \times v_3) + (0.040 \times 1.2)$$

$$0.075 + 0 = 0.050 \times v_3 + 0.048$$

$$0.027 = 0.050 \times v_3$$

$$\frac{0.027}{0.050} = v_3$$

$$v_3 = 0.54 \text{ m s}^{-1} \text{ (2sf)}$$

- (c) If the duration of the collision was 0.08 seconds, calculate the average force that the red car exerts on the blue car.

$$F = ma$$

$$a = \frac{\Delta v}{\Delta t}$$

$$a = \frac{1.5}{0.08}$$

$$a_{(\text{red car})} = 18.75 \text{ ms}^{-2}$$

$$F = ma$$

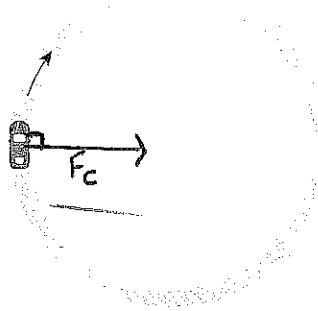
$$F = 0.050 \times 18.75$$

~~$$F = 0.05$$~~

$$F = 0.9375$$

$$F = 0.9 \text{ N (1sf)}$$

- (d) On another occasion the red car was going round a circular part of the track at a constant speed.



- (i) Name the force acting on the car, and draw a labelled vector on the diagram above to show the direction of the force acting on the car at the instant shown.

Centripetal force

- (ii) Discuss the effect of the force on the size and direction of the velocity of the red car.

The centripetal force acts on the car at right angles ~~to the~~ inwards/towards the centre of motion. The centripetal force causes the car to travel in a circular path. The larger the centripetal force acting on the car, the more the car will turn around sharper the circular path will be that the car follows.

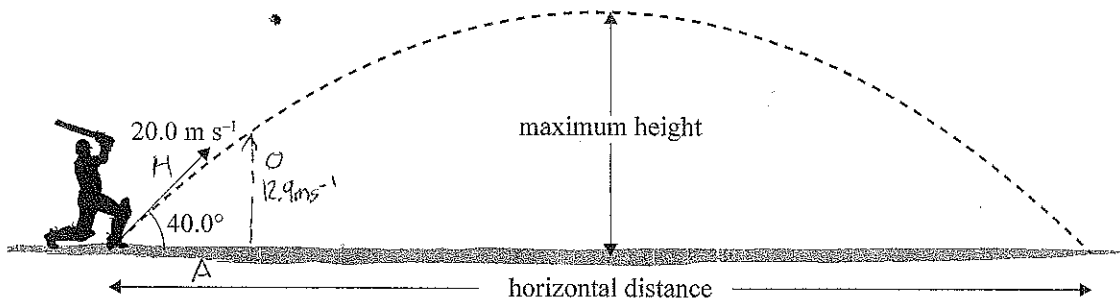
If the centripetal force causes the car to accelerate around a corner by changing its direction, even though the velocity of the car remains constant.

a

M5

QUESTION TWO: PROJECTILE MOTION

During a cricket game a batsman hits the ball at an angle of 40.0° with the ground at a velocity of 20.0 m s^{-1} , as shown below.



www.wallpaperzworld.com/Cricket-Batsman-wallpaper_1576_original-view

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- (a) Show that the initial vertical component of the ball's velocity is 12.9 m s^{-1} .

$$\sin \theta = \frac{O}{H}$$

$$\sin 40^\circ = \frac{O}{20.0}$$

$$20 \sin 40 = O$$

$$12.855 = O$$

$$O = 12.9 \text{ m s}^{-1}$$

initial vertical component of the balls velocity
= 12.9 m s^{-1}

- (b) Calculate the time it takes the ball to reach its maximum height.

$$V_f = V_i + at$$

$$0 = 20 + (-9.8)t$$

$$0 = 20 - 9.8t$$

$$-20 = -9.8t$$

$$\frac{-20}{-9.8} = t$$

$$2.04 = t$$

$$t = 2.04 \text{ s (3sf)}$$

- (c) Calculate the horizontal distance travelled by the ball before it hits the ground.

Total time = $2 \times$ time to reach max height

$$d = \frac{V_i + V_f}{2} t$$

$$d = \frac{20 + 20}{2} \times 4.08$$

$$d = 20 \times 4.08$$

$$d = 81.6 \text{ m}$$

therefore $20.0 \text{ m s}^{-1} = 20.0 \text{ m s}^{-1}$

- (d) Give a comprehensive explanation of the effect of the force(s) acting on the ball during its flight. Assume air resistance is negligible.

In your answer you should:

- describe the horizontal motion
- discuss the effect of force(s) on horizontal motion
- describe the vertical motion
- discuss the effect of force(s) on vertical motion.

During its flight, the ball has a constant vertical acceleration due to the force of gravity acting on it in the downwards direction, of 9.8ms^{-2} . When the ball is travelling upwards, it is decelerating at 9.8ms^{-2} . When the ball is travelling downwards, it is accelerating at 9.8ms^{-2} . The ball has a constant horizontal velocity ~~in the~~ due to the fact that there are no forces ~~in~~ acting on it in the horizontal direction.

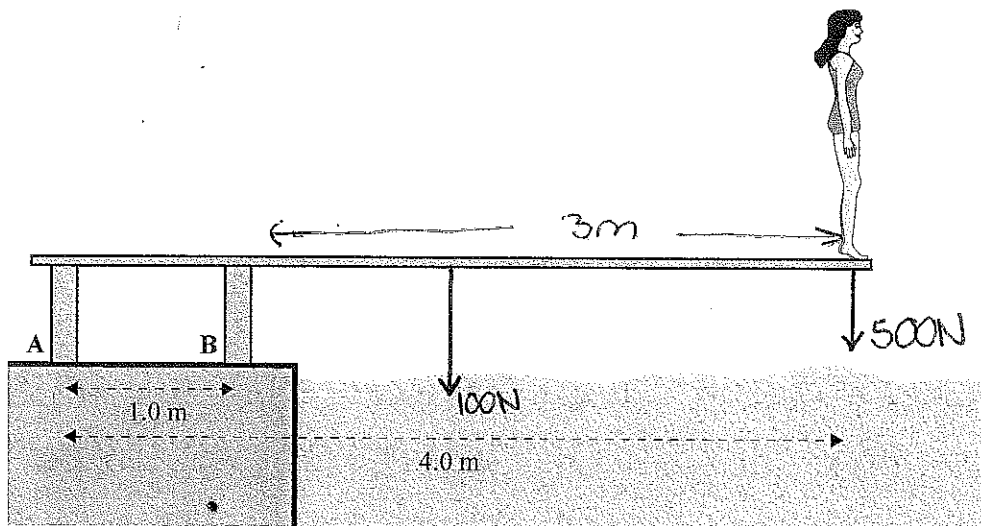
The ball does not have a constant velocity in the vertical component of motion, and does not have a constant acceleration in the horizontal component of motion.

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e

M6

QUESTION THREE: TORQUES AND ENERGY

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Sarah stands at the end of a diving board of total length 4.0 m. The diving board is fixed to two supports, A and B, which are 1.0 m apart. The mass of the board is 10 kg and Sarah's mass is 50 kg. Assume the mass of the board is evenly distributed.

- (a) Calculate the torque exerted by Sarah about support B.

Give units with the answer.

$$T = Fd$$

$$T = 500\text{N} \times 3$$

$$T = 1500\text{Nm}$$

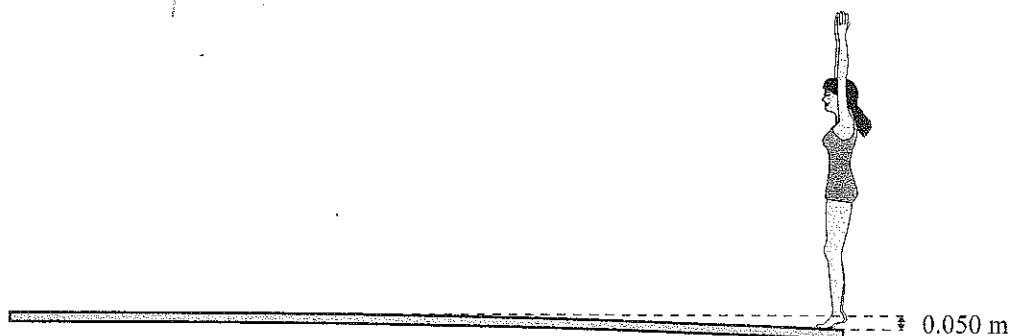
- (b) What is the direction of the force supplied by support A?

Explain your answer.

No calculations are required.

The direction of the force supplied by support A is upwards. Support A has to supply a force upwards to hold the diving board above the ground and act against the force of gravity that is supplying a downwards force on the diving board (at point A).

- (c) The diving board sags 0.050 m when Sarah stands still on the end of the board.



Calculate the spring constant of the board (assuming the board acts like a spring).

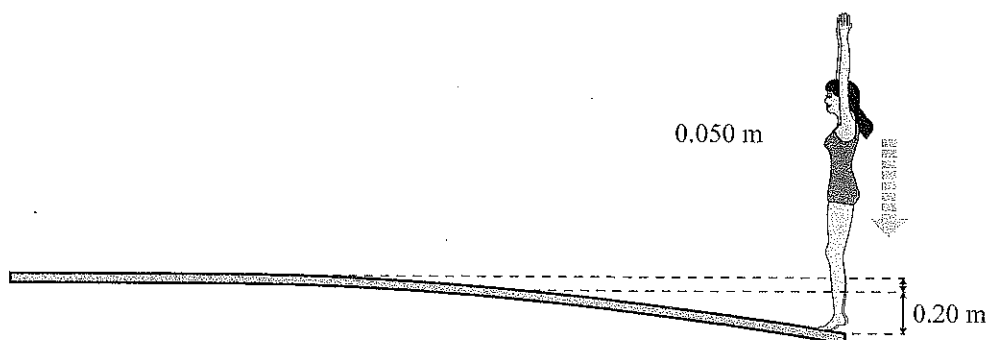
$$F = kx$$

$$500\text{ N} = k \times 0.050$$

$$k = \frac{500}{0.050}$$

$$k = 10,000\text{ N m}^{-1}$$

- (d) Sarah then jumps up and lands on the board, depressing it by a further 0.20 m before she dives into water, as shown below.



Calculate Sarah's speed when she lands on the board, causing it to depress it by a further 0.20 m.

$$F = kx$$

$$\text{Total } k = \frac{F}{x}$$

$$k = \frac{500}{0.050 + 0.20}$$

$$k = 0.25$$

$$k = 2000\text{ N m}^{-1}$$

$$E_p = E_k$$

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

$$\frac{1}{2} \times (2000) \times (0.25)^2 = \frac{1}{2} \times (50) \times v^2$$

$$62.5 = 25v^2$$

$$2.5 = v^2$$

$$\sqrt{2.5} = v$$

$$v = 1.58$$

$$v = 1.6\text{ m s}^{-1} \text{ (2sf)}$$

Merit exemplar 2016

Subject: PHYSICS		Standard: 91171	Total score: 16
Q	Grade score	Annotation	
1	M5	Overall, this is a Merit level response. The candidate uses an invalid relationship in the attempt to solve the problem in part (a), but presents a clearly set out and correct solution in part (b). Part marks are gained in (c) where the response shows some understanding of the concept. The answer to part (d) is 'm' rather than 'a' because the candidate links the force to the change in direction of the car's velocity, but 'm' rather than 'e' because the fact that the force is at right angles to the direction of gravel is not linked to it having no effect on the size of the velocity	
2	M6	This response provides good evidence for Merit. The candidate's solutions to the numerical problems in parts (b) and (c) show a lack of understanding that component velocities need to be used for vertical and horizontal motion. However, the discussion in part (d) is clear, concise and at the 'e' level	
3	M5	The answer to this question demonstrates understanding at the Merit level. The candidate did well to write the correct units in part (a) as this was a failure of many other candidates. The explanation in part (b) required application of a familiar concept in an unfamiliar situation and the candidate is unable to do so. The calculation in part (c) is carried out in a straightforward manner (candidates who used 10 N kg^{-1} instead of 9.8 N kg^{-1} were not penalised) but for some reason a new value for 'k' is calculated unnecessarily in the solution to part (d), thus scoring 'm' rather than 'e'	