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2

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Tick this box if there is no writing in this booklet

Level 2 Physics 2020

91171 Demonstrate understanding of mechanics

9.30 a.m. Monday 16 November 2020
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 2–12 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.

TOTAL

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QUESTION ONE: IN TOWN

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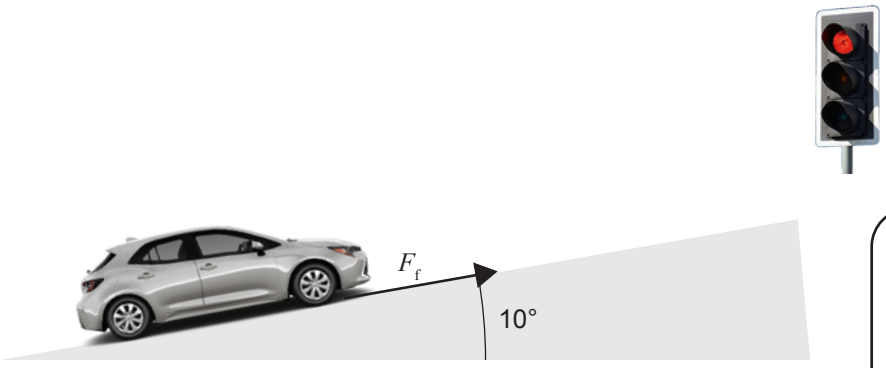
Alex and Jo have decided to take a road trip. They start from rest on a straight road, and accelerate at 4.2 m s^{-2}.

(a) Show their velocity after 0.60 seconds is 2.5 m s^{-1}.

(b) While waiting at traffic lights, Jo has to put on the handbrake to stop the car rolling down the steep (10°) slope they are on. The mass of the car and occupants is 1600 kg.



If you need to redraw your labelled arrows, use the spare diagram on page 9.

Adapted from: www.auto123.com/en/new-cars/technical-specs/toyota/corolla/2019/hatchback/base/
www.luxreview.com/2016/08/17/smart-traffic-lights-to-talk-to-drivers/

The diagram above shows the friction force acting between the tyres and the road.

(i) Add **labelled** arrows to show the other two forces acting on the stationary car.

(ii) Complete a **labelled** vector diagram showing how all three forces add together.

If you need to redraw your vector diagram, use the spare diagram on page 9.

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(c) By first working out the force of gravity on the car, show that the value of the friction force required to keep the car stationary is 2700 N.

(d) While travelling at 50 km h^{-1}, Jo sees a pothole in the road 15 m ahead. She must reduce her speed from 50 km h^{-1} to 20 km h^{-1} to avoid damaging the car.

If the time needed for safe braking from 50 km h^{-1} to 20 km h^{-1} is 2.3 seconds, show by calculation whether there is enough time to complete braking before reaching the pothole.

You should start by showing that 50 km h^{-1} = 13.89 m s^{-1}.

QUESTION TWO: OPEN ROAD

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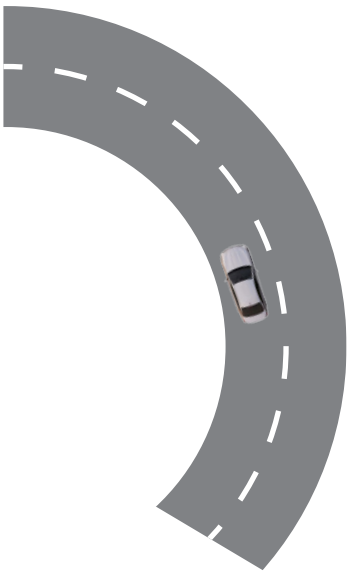
Jo and Alex continue their drive and take a sharp bend in the road at a constant speed of 12 m s^{-1}.



If you need to redraw your arrow, use the spare diagram on page 10.

(a) Draw an arrow on the car on the diagram above to show the direction of the acceleration at this point.

(b) Calculate the size of the acceleration if the radius of the bend is 25 m, and explain what causes this acceleration.

(c) State TWO external factors that could change the motion of the car as it travels around the corner, and explain how these factors would affect the motion.

(d) The pair continue on their journey at a constant speed of 12 m s^{-1}. The car is fitted with a crumple zone. Alex says the crumple zone can increase the time of impact in a collision from 0.2 seconds to 0.8 seconds.

The mass of the car and occupants is 1600 kg.

Use physics principles and appropriate calculation(s) to explain how having a crumple zone can make this car safer for the occupants during a collision.

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QUESTION THREE: THE BRIDGE

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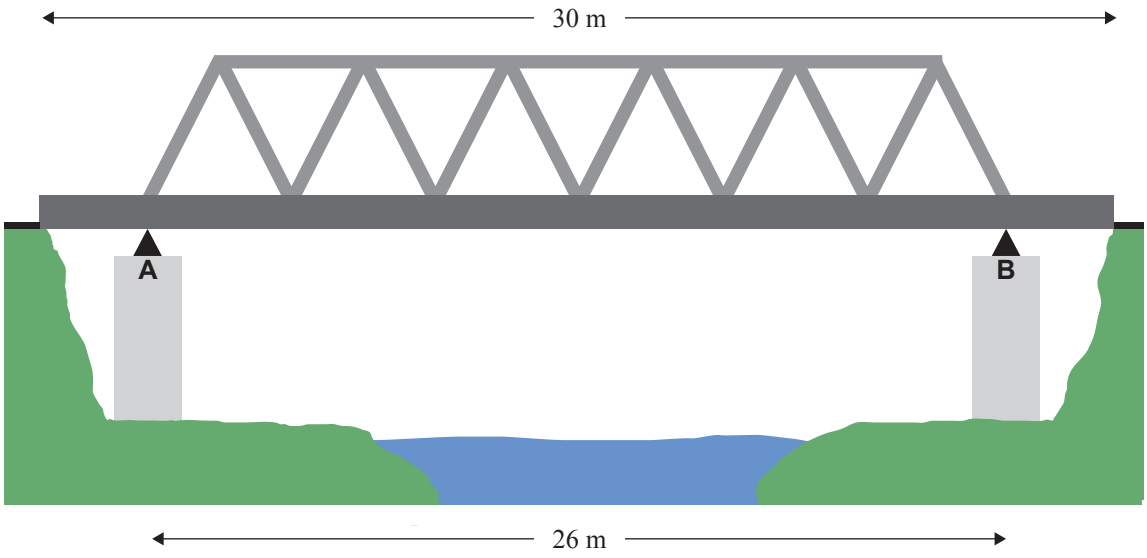
Jo and Alex need to cross a bridge to reach their destination.

www.flickr.com/photos/21663749@N03/5225413303



The bridge is 30 m long, and has a mass of 30 000 kg.

The supports are 26 m apart, and equal distance from the centre of the bridge.

(a) State the two requirements for an object to be in equilibrium.

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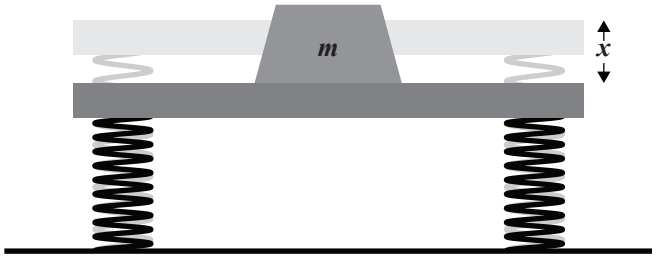
(b) The road is closed as the bridge is under repair. The support column at end B can supply a maximum support force of 160 000 N.

By finding torques about support A, calculate the furthest distance from support A that a 1600 kg mass could be placed before the support at B became overloaded.

(c) The bridge has an earthquake-protection system made up of springs. Before being put in place on the bridge, the springs are tested by being loaded with a mass m. When loaded with a mass m the springs compress by a distance x.



Explain, in depth, how the size of the mass on the springs needs to change in order to compress the springs a distance $2x$ from the original length.

Question Three continues on the following page.

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(d) Jo and Alex wonder whether a compressed spring from the bridge could accelerate their car once the spring is released, as in the diagram below. They decide to determine the effect of the spring on the car's motion. They estimate that for this spring, a force of 50 000 N would compress the spring length from 6.0 m to 4.2 m. The total mass of the car and occupants is 1600 kg.

(i) Calculate the maximum speed to which this spring could accelerate the car and its occupants if it was compressed to 4.2 m.

You should start your answer by first determining the spring constant, k.

(ii) What assumption(s) have you made in this calculation?

SPARE DIAGRAMS

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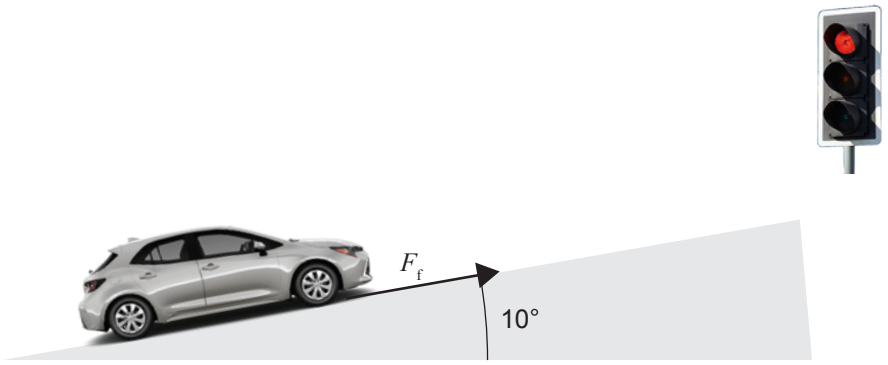
If you need to redraw your labelled arrows for Question One (b)(i), use the diagram below. Make sure it is clear which diagram you want marked.



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www.luxreview.com/2016/08/17/smart-traffic-lights-to-talk-to-drivers/

If you need to redraw your vector diagram for Question One (b)(ii), use the diagram below. Make sure it is clear which diagram you want marked.

If you need to redraw your arrow for Question Two (a), use the diagram below. Make sure it is clear which diagram you want marked.

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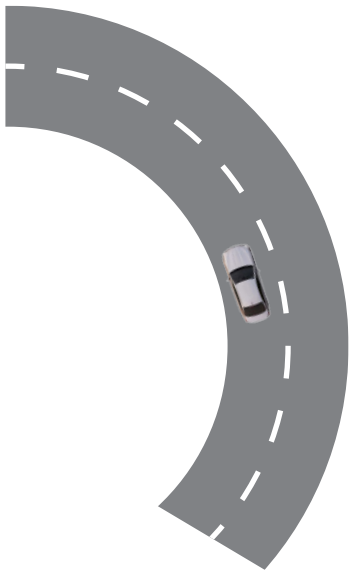

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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