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915240

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QUALIFY FOR THE FUTURE WORLD
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Tick this box if you have NOT written in this booklet

Level 3 Physics 2022

91524 Demonstrate understanding of mechanical systems

Credits: Six

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

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 Booklet L3–PHYSR.

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

Numerical answers should be given with an SI unit, to an appropriate number of significant figures.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area ( ). This area may be cut off when the booklet is marked.

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

QUESTION ONE: ROTATIONAL MOTION AT THE PLAYGROUND

Some children are playing on a roundabout.

Source: www.rehabmart.com/product/merry-go-round-44540.html

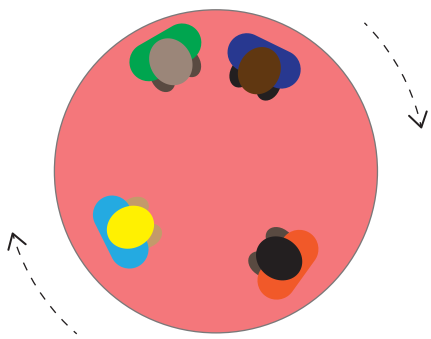
Riley pushes the roundabout and gets it spinning at a constant angular speed. It makes one revolution in 1.23 s.

(a) Show that the angular velocity of the roundabout is 5.11 rad s^{-1}.

(b) Riley stops pushing, and 30.0 s later the roundabout has slowed, so that it takes 2.04 s to make one revolution. The roundabout can be approximated to a spinning disc with a rotational inertia of 57.6 kg m^2.

- Determine the average angular deceleration of the roundabout as it slows.
- Calculate the average frictional torque acting on the roundabout as it slows.

(c) Four friends all ride on the roundabout, in the positions shown in the diagram.

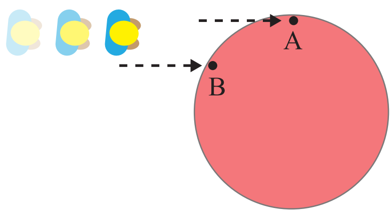


Explain, using physics principles, what the friends can do to make the roundabout speed up while staying on the platform.

Exclude all influences external to the platform.

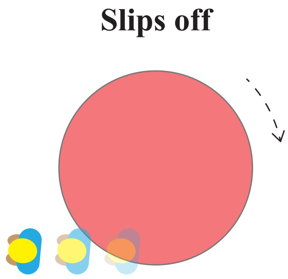
(d) Matilda wants to run and jump onto the (initially stationary) roundabout, holding onto poles at A or B to make it spin as fast as possible. She tries different jumps onto the roundabout.

Jumps on



(i) Assuming that she always jumps at the same speed, explain which jump, Jump A or Jump B, will make the roundabout go round faster.

(ii) Matilda subsequently lets go of the pole and slips off the roundabout.



Discuss the possible effects on the speed of the roundabout.

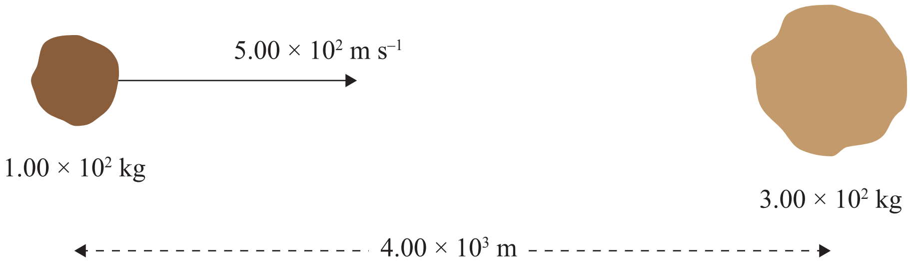
Assume there is negligible friction between Matilda and the roundabout.

QUESTION TWO: COLLISIONS IN SPACE

Comets and asteroids are loosely formed objects that are easily broken up, especially when they collide.

In this scenario a 1.00×10^2 kg object moving with a velocity of 5.00×10^2 m s^{-1} collides with a stationary, 3.00×10^2 kg object.

Before collision



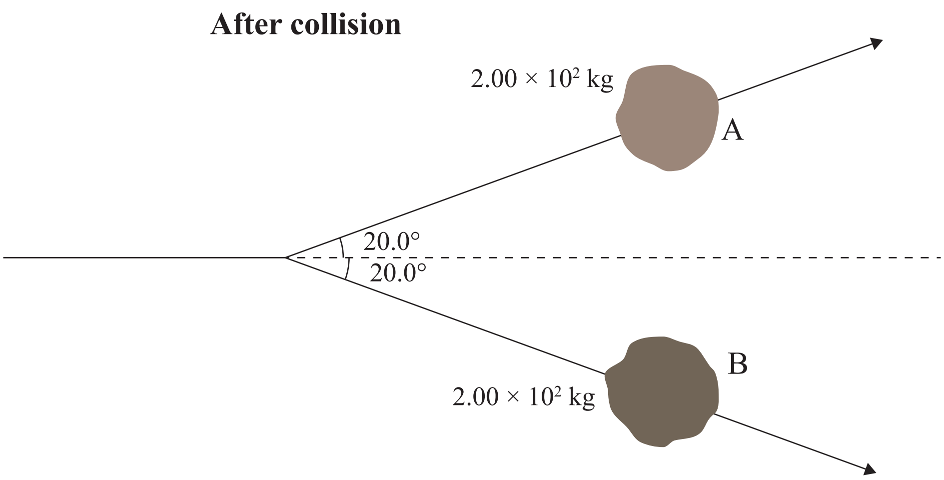
(a) Calculate the distance of the centre of mass of the system from the 3.00×10^2 kg object when the objects are 4.00×10^3 m apart.

(b) (i) Calculate the gravitational force between the two objects, when their centres of mass are 10.0 m apart.

Assume that the velocities of the masses are constant before the collision.

(ii) Hence find the acceleration of the 1.00×10^2 kg object at this separation, to determine whether the assumption that their velocities are constant before the collision is valid.

(c) The objects collide, with no external forces, and form two 'rocks', A and B, each with a mass of 2.00×10^2 kg. These move away from each other, as shown in the diagram, in directions at 20° either side of the initial direction of the impacting rock.



Show that the size of the momentum of rocks A and B are the same, even though they are in different directions. You may use the space below to draw vector diagrams.

If you need to redraw your response, use the space on page 10.

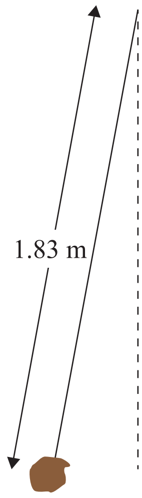
(d) Calculate the speed of rocks A and B. You may use the space below to draw vector diagrams.

Begin your answer by calculating the total momentum before collision.

If you need to redraw your response, use the space on page 10.

QUESTION THREE: A PENDULUM ON MARS

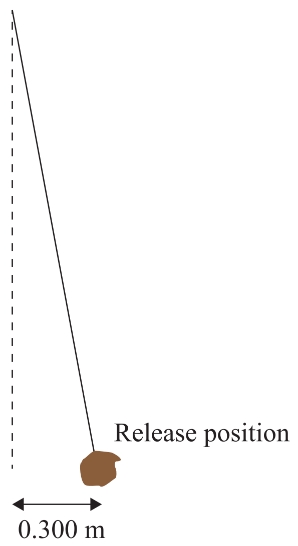
Some space explorers on Mars want to check that their electronic timers are functioning correctly. They make a simple pendulum, using a large rock, mass 2.30 kg, tied to a wire.

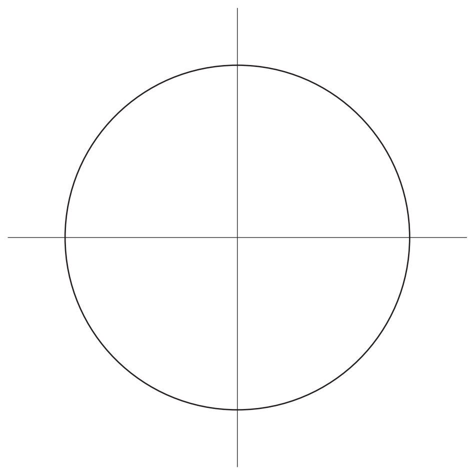


(a) The distance from the centre of mass of the rock to the fixing point is 1.83 m. On Mars, the gravitational field strength is 3.72 N kg^{-1}.

Show that the time period of the pendulum is 4.41 s.

(b) They set the pendulum oscillating by releasing the pendulum bob 0.300 m away from its rest position, and at the same moment they start a timer.





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

Determine the position of the pendulum bob from its release point 2.00 s after it is released. You may use the space above to draw a phasor diagram to help your calculation.

(c) The amplitude of the pendulum decreases from 0.300 m to 0.200 m.

Explain why the period of the pendulum remains unchanged.

(d) Calculate the total energy lost when the amplitude decreases from 0.300 m to 0.200 m.

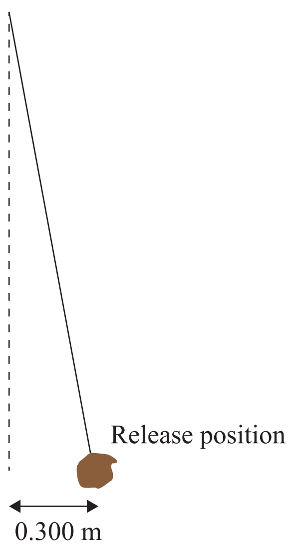
Begin your answer by calculating the maximum velocity of the bob for the initial and the final amplitude.

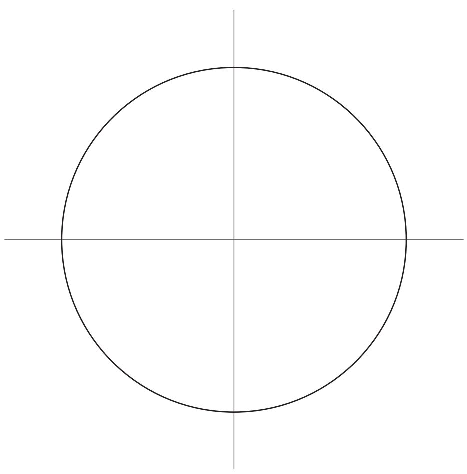
SPARE DIAGRAMS

If you need to redraw your response to Question Two (c), use the space below. Make sure it is clear which answer you want marked.

If you need to redraw your response to Question Two (d), use the space below. Make sure it is clear which answer you want marked.

If you need to redraw your response to Question Three (b), use the diagram below. Make sure it is clear which answer you want marked.





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

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