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91524

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NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 3 Physics, 2014

91524 Demonstrate understanding of mechanical systems

2.00 pm Tuesday 25 November 2014
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 2–8 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.

TOTAL

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QUESTION ONE: ROTATIONAL MOTION

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Universal gravitational constant = 6.67×10^{-11} N m^2 kg^{-2}

(a) The radius of the Sun is 6.96×10^8 m. The equator of the Sun rotates at a rate of 14.7 degrees per day.

(i) Show that the period of rotation of a particle located on the equator of the Sun is 2.12×10^6 s.

(ii) Calculate the linear speed of a particle at the Sun's equator.

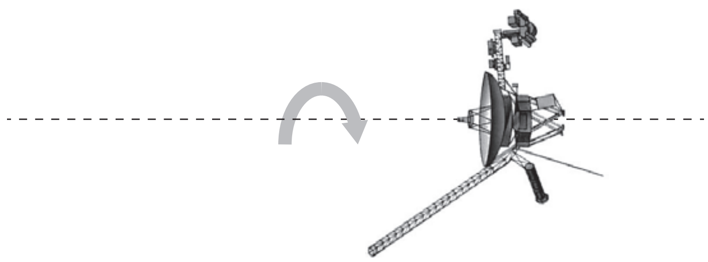
(b) Gravity may cause the rotating inner core of the Sun to collapse down to a much smaller radius.

Explain how this will affect the angular speed of the inner core.

(c) The mass of Mercury is 3.30×10^{23} kg. Mercury has a period of rotation of 5.067×10^{6} s.

Show that a satellite needs to be positioned 2.43×10^{8} m from the centre of Mercury so that it remains stationary from the point-of-view of an observer on that planet.

(d) A space probe spins around an axis, as shown below.



An instrument comes loose from the space probe.

Explain why this loss of mass will have no effect on the angular speed of the space probe.

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QUESTION TWO: THE PENDULUM

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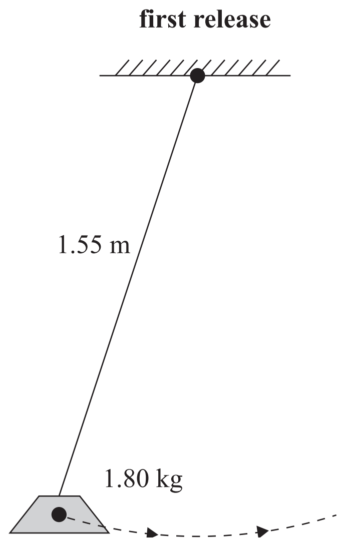
Acceleration due to gravity of Earth = 9.81 m s^{-2}.

A pendulum is set up, as shown in the diagram. The length of the cord attached to the bob is 1.55 m. The bob has a mass of 1.80 kg.



(a) Calculate the time it takes for the pendulum bob to swing from one side to the other.

(b) Explain how the forces acting on the bob change the bob's speed as it travels from the point of release to the centre.

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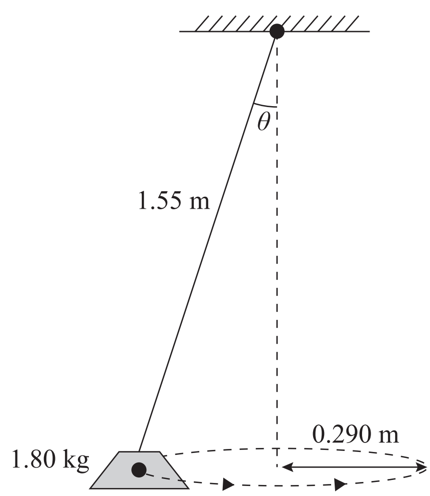
(c) The bob is released again in such a way that it swings in a horizontal circular path, with radius 0.290 m, as a conical pendulum.



(i) By first calculating the size of the angle that the cord makes with the vertical, show that the tension force in the cord is 18.0 N.

(ii) Calculate the speed that the mass must have been given when released, in order to attain a horizontal circular path at a radius of 0.290 m.

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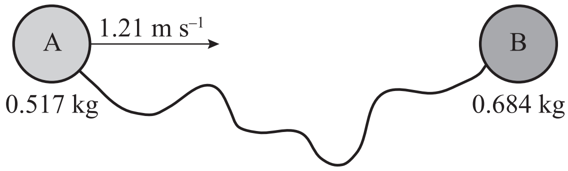
QUESTION THREE: TRANSLATIONAL MOTION

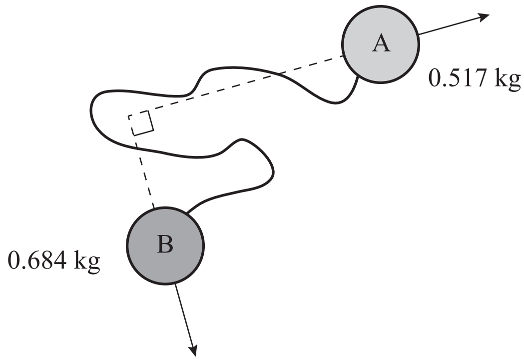
A system consists of two discs, A and B, attached together with a light cord. The discs slide across a frictionless surface. Disc A has mass 0.517 kg and disc B has mass 0.684 kg. Disc B is stationary, and disc A is moving towards disc B with a speed of 1.21 m s^{-1}.



(a) Show that the speed of the centre of mass of the system is 0.521 m s^{-1}.

Show all your working.

(b) The discs collide and after the collision they are moving at right angles to each other. Disc A receives an impulse of 0.250 N s.



(i) Show that the speed of disc B after the collision is 0.365 m s^{-1}.

Explain your reasoning.

(ii) Determine the size of the momentum of disc A after the collision.

(c) The discs continue to slide until the cord is fully extended. When this happens, both discs change their speed and direction.

By considering the force(s) that act on the discs, explain why the momentum of the system must be conserved.

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

QUESTION NUMBER

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