3

91524

915240

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

SUPERVISOR'S USE ONLY

Level 3 Physics, 2013

91524 Demonstrate understanding of mechanical systems

2.00 pm Monday 25 November 2013
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.

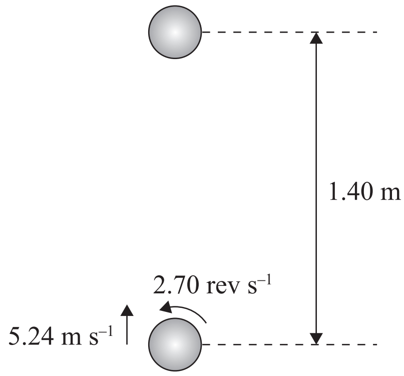
TOTAL

ASSESSOR'S USE ONLY

You are advised to spend 60 minutes answering the questions in this booklet.

ASSESSOR'S USE ONLY

QUESTION ONE: TOSSING BALLS



A hollow ball has a mass of 0.310 kg and radius 0.0340 m. The ball is thrown vertically upwards from rest. It rises through a height of 1.40 m then drops down again. When it is released, it is moving upwards at 5.24 m s^{-1} and rotating at 2.70 revolutions per second.

During the throwing action, a tangential force of 0.480 N is applied to the surface of the ball for a period of 0.250 s.

(a) Show that the angular speed of the ball when it is released is 17.0 rad s^{-1}.

(b) Show that the average angular acceleration of the ball before it is released is 67.9 rad s^{-2}.

(c) Calculate the rotational inertia of the ball.

ASSESSOR'S USE ONLY

(d) For the following two situations, explain whether the height to which the ball rises will be less than, greater than, or the same as 1.40 m.

Ignore the effects of air resistance.

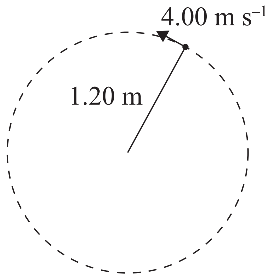
(i) The ball is **not** rotating, but is given the **same** linear speed when it is released.

(ii) The ball is **solid** instead of hollow, but has the **same** mass and radius. The same amount of total work is done to give the ball its linear and rotational motion, and it has the same angular speed.

ASSESSOR'S USE ONLY

QUESTION TWO: SWINGING BALLS

A ball on the end of a cord of length 1.20 m is swung in a vertical circle. The mass of the ball is 0.250 kg. When the ball is in the position shown in the diagram, its speed is 4.00 m s^{-1}.



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

(a) Calculate the size of the centripetal force acting on the ball at the instant shown in the diagram.

(b) Explain why the ball moves fastest at the bottom of the circle.

(c) (i) Diagram 1 shows the gravitational force acting on the ball at the top and bottom of the swing.

Assuming the tension force is non-zero at all points, draw vectors to show the relative sizes of tension forces at the top and bottom.

(ii) Using the same scale, draw the **centripetal force**, on Diagram 2, at these two positions.

Diagram 1

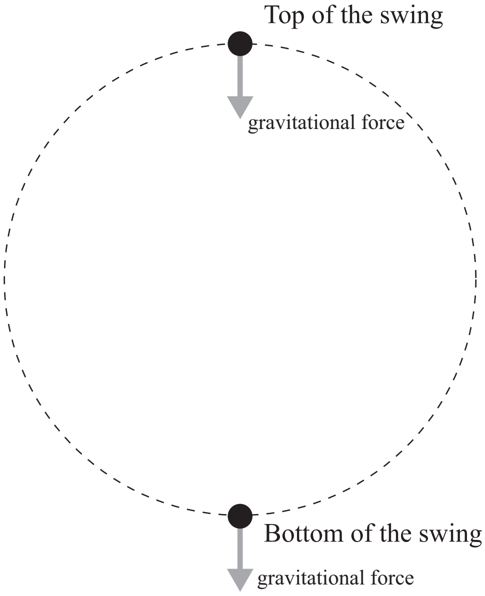
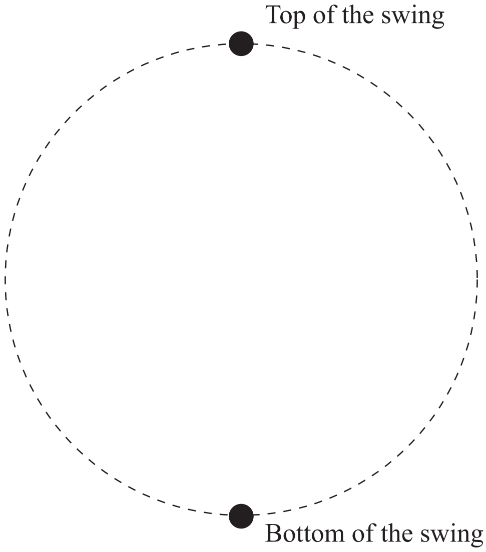


Diagram 2



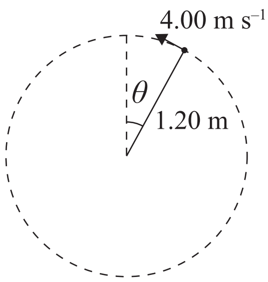
(d) Show that the minimum speed the ball must have during its circular motion is 3.43 m s^{-1} at the top.

Explain your answer.

ASSESSOR'S USE ONLY

(e) The ball drops to its minimum speed of 3.43 m s^{-1} at the top of the circle.

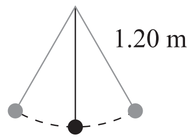
Using conservation of energy, show that the angle at which the tangential speed of the ball is 4.00 m s^{-1}, is $\theta = 34.9°$.



QUESTION THREE: OSCILLATING BALLS

ASSESSOR'S USE ONLY

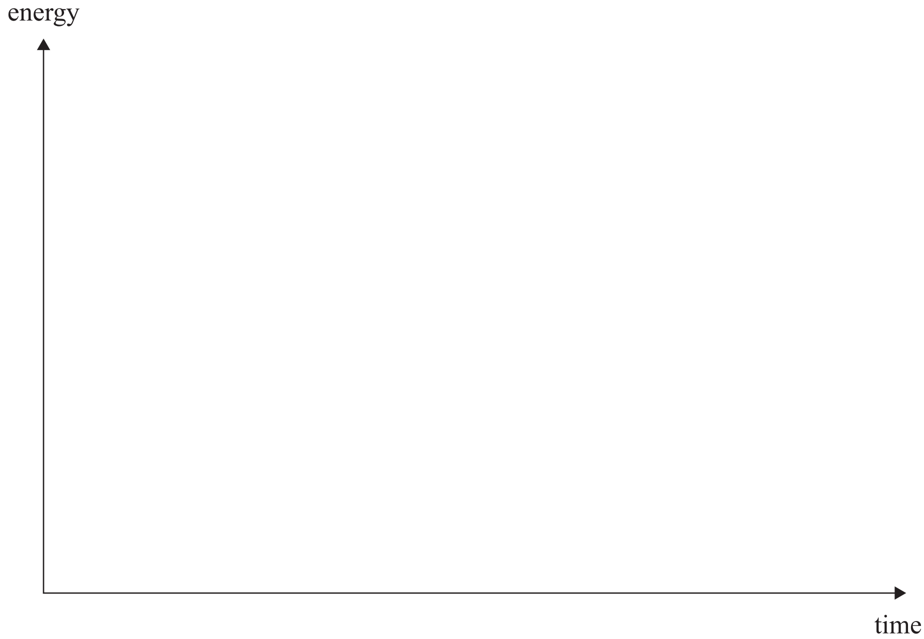
A ball, attached to a cord of length 1.20 m, is set in motion so that it is swinging backwards and forwards like a pendulum.



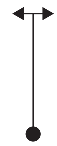
(a) Show that the period of a pendulum of length 1.20 m that is oscillating in simple harmonic motion is 2.20 s.

(b) Explain what must be done to ensure that the motion of the ball approximates simple harmonic motion.

(c) On the axes below, sketch a graph to show what happens to the ball's **total** energy over time until it stops swinging.



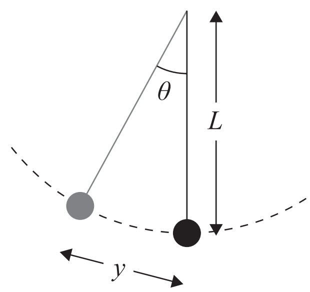
(d) It is possible to get the ball swinging by holding the top end of the cord and gently shaking it backwards and forwards.



Explain how shaking the top end of the cord can make the ball on the bottom of the cord oscillate in simple harmonic motion.

In your answer, you should consider resonance and energy transfer.

(e) Simple harmonic motion requires a restoring force that changes in proportion to the size of the displacement.



Discuss what provides the restoring force when the ball is swinging in simple harmonic motion.

In your answer, you should:

- describe what forces act on the ball
- explain how these forces change as the ball swings
- draw vectors to show how a restoring force is produced.

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

QUESTION NUMBER

ASSESSOR'S USE ONLY