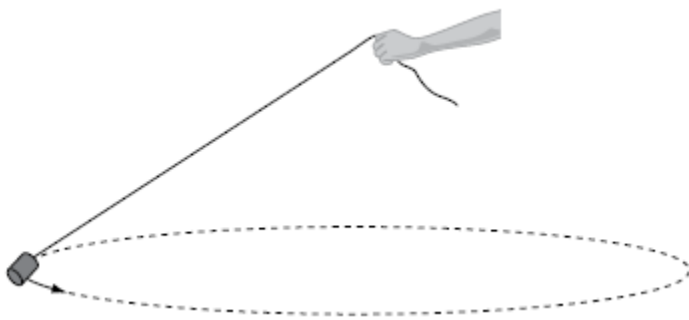1. **a** Explain what is meant by a radian.
    b A body moves round a circle at a constant speed and completes one revolution in 15 s. Calculate the
    angular velocity of the body.

2. **a** Explain what is meant by the term angular velocity.
    b Figure below shows a rubber bung, of mass 200 g, on the end of a length of string being swung
    in a horizontal circle of radius 40 cm. The string makes an angle of 56° with the vertical.

Calculate:
i the tension in the string.
ii the angular velocity of the bung.
iii the time it takes to make one complete revolution.

3. **a.** Explain what is meant by a centripetal force.
    b A teacher swings a bucket of water, of total mass 5.4 kg, round in a vertical circle of diameter 1.8 m.
    i Calculate the minimum speed which the bucket must be swung at so that the water remains in
    the bucket at the top of the circle.
    ii Assuming that the speed remains constant, what will be the force on the teacher's hand when
    the bucket is at the bottom of the circle?

4. **a** Show that in one revolution there are 2π radians. [2]
    b Figure below shows a centrifuge used to separate solid particles suspended in a liquid of lower density.

10 cm
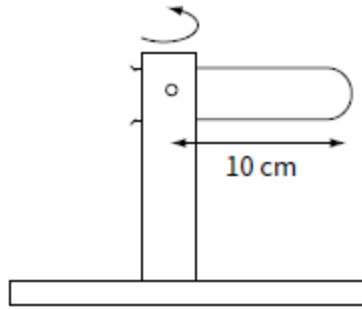
The container is spun at a rate of 540 revolutions per minute.

i Calculate the angular velocity of the container. [2]

ii Calculate the centripetal force on a particle of mass 20 mg at the end of the test tube. [2]

c An alternative method of separating the particles from the liquid is to allow them to settle to the bottom of a stationary container under gravity. By comparing the forces involved, explain why the centrifuge is a more effective method of separating the mixture.

5. The earth has a radius of 6380 km and turns around once on its axis in 24 h.

(a) What is the radial acceleration of an object at the earth's equator? Give your answer in m>s2 and as a fraction of g.

(b) If a_{rad} at the equator is greater than g, objects will fly off the earth's surface and into space. What would the period of the earth's rotation have to be for this to occur?

6. A model of a helicopter rotor has four blades, each 3.40 m long from the central shaft to the blade tip. The model is rotated in a wind tunnel at 550 rev/min.

(a) What is the linear speed of the blade tip, in m>s?

(b) What is the radial acceleration of the blade tip expressed as a multiple of g?

7. At its Ames Research Center, NASA uses its large "20-G" centrifuge to test the effects of very large accelerations ("hyper gravity") on test pilots and astronauts. In this device, an arm 8.84 m long rotates about one end in a horizontal plane, and an astronaut is strapped in at the other end. Suppose that he is aligned along the centrifuge's arm with his head at the outermost end. The maximum sustained acceleration to which humans are subjected in this device is typically 12.5g.

(a) How fast must the astronaut's head be moving to experience this maximum acceleration?

(b) What is the *difference* between the acceleration of his head and feet if the astronaut is 2.00 m tall?

(c) How fast in rpm is the arm turning to produce the maximum sustained acceleration?