WEBSITE PROBLEMS: **CIRCULAR MOTION**

Level 4

Exercise 1: When a particle travels in a circle of radius r with constant speed v, its acceleration is:

a) $\frac{v^2}{r}$ towards the centre.

b) $\frac{v^2}{r}$ away from the centre.

c) zero

d) rv^2 towards the centre.

e) rv^2 away from the centre.

[*Used with permission from UCLES, AO Level Physics, June 1989, Paper 1, Question 10.*]

Exercise 2: An artificial satellite travels in a circular orbit about the Earth. Its rocket engine is then fired and produces a force on the satellite exactly equal and opposite to that exerted by the Earth's gravitational field. The satellite would then start to move:

a) along a spiral path towards the Earth's surface.

b) along the line joining it to the centre of the Earth (i.e. radially).

c) along a tangent to the orbit.

d) in a circular orbit with a longer period.

e) in a circular orbit with a shorter period.

[*Used with permission from UCLES, A Level Physics, June 1988, Paper 1, Question 7.*]

Exercise 3: The second hand of a large clock is 3.0 m long. What is its mean angular speed?

a) 1.4×10^{-4} rad s^{-1}

b) 1.7×10^{-3} rad s^{-1}

c) 5.2×10^{-3} rad s^{-1}

d) 1.0×10^{-1} rad s^{-1}

e) 3.0×10^{-1} rad s^{-1}

[*Used with permission from UCLES, A Level Physics, June 1987, Paper 1, Question 7.*]

Exercise 4: A mass, m of 0.050 kg is attached to one end of a piece of elastic of unstretched length, $l = 0.50$ m. The force constant, k of the elastic (i.e. the force required to produce unit extension) is 40 N m^{-1}. The mass is rotated steadily on a smooth table around a fixed point in a horizontal circle of radius $r = 0.70$ m. What is the approximate speed of the mass?

a) 11 m s^{-1}

b) 15 m s^{-1}

c) 20 m s^{-1}

d) 24 m s^{-1}

e) 28 m s^{-1}

[*Adapted with permission from UCLES, A Level Physics, June 1987, Paper 1, Question 9.*]

Exercise 5: Find the speed of a satellite in a circular orbit around the Moon, very near the Moon's surface. What is the kinetic energy per unit mass of the satellite? The gravitational force F_A between the satellite and the Moon is in the inward radial direction and its magnitude is given by the equation

$$F_A = GMm/R^2$$

where G is the gravitational constant; M and m are the masses of the Moon and the satellite respectively; and R is the radius of the orbit. Give your answer to two decimal places.

Hint: The radius of the Moon is 1.74×10^6 m, the mass of the Moon is 7.35×10^{22} kg and Newton's Gravitational Constant, $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}. [*Used with permission from UCLES, A Level Physics, November 1988, Paper 2, Question 3.*]

Exercise 6: A record is played at 45 rpm, and then slowed down to $33\frac{1}{3}$ rpm. Find the ratio of the magnitude of the centripetal accelerations of a point on the rim of the record before and after the change. Write your answer to two decimal places. [*Used with permission from UCLES, A Physics, November 1986, Paper 2, Question 2.*]

Exercise 7: A satellite is to be placed in a circular orbit around the Earth. Use the information and data below to calculate the required radius of the orbit if the satellite is in a geostationary orbit (remains above the same point on the equator).
The gravitational force F_A between the satellite and the Earth is in the inward radial direction and its magnitude is given by the equation

$$F_A = GMm/R^2$$

where G is the gravitational constant; M and m are the masses of the Earth and the satellite respectively; and R is the radius of the orbit. Please give your answer to two significant figures.

Hint: $G = 6.67 \times 10^{-11}$ m^3 kg^{-1} s^{-2}
$M = 5.97 \times 10^{24}$ kg [*Used with permission from UCLES, A Level Physical Science, June 1989, Paper 2, Question 3.*]

Exercise 8: The reading of a speedometer fitted to the front wheel of a bicycle is directly proportional to the angular speed of the wheel. A certain speedometer is correctly calibrated for use with a wheel of diameter 66 cm but, by mistake, is fitted to a 60 cm wheel. Explain whether the indicated linear speed would be greater or less than the actual linear speed and find the percentage error in the readings. [*Used with permission from UCLES, A Level Physics, June 1984, Paper 1, Question 1.*]

Exercise 9: A fairground ride consists of a rough cylinder that rotates about a vertical axis through its centre. Once people are inside and the cylinder is rotating fast enough the floor is removed but the thrillseekers do not fall down. If the coefficient of friction between the people and the cylinders is μ and the cylinder has radius R, what is the minimum angular speed at which it needs to rotate for the ride to be safe? [*Created for the Rutherford School Physics Project by NHB and ES*]

Exercise 10:

a) A car approaches a roundabout of radius R. What is the maximum speed at which it can travel in order to go around without slipping, if the coefficient of friction between the road and car is μ?

b) This time a racing car approaches a corner of radius R, banked at an angle θ to the horizontal.

   i. What is the maximum speed at which the car can travel if it is icy so there is no friction between the wheels and the road?

   ii. What is the maximum speed at which the car can travel and not slip if the road is rough, with coefficient of friction is μ?

   iii. Is there a minimum speed at which the car needs to travel when the road is rough, with coefficient of friction μ?

[*Created for the Rutherford School Physics Project by NHB and ES*]