7 **(a)** A student investigates the power output of a remote-control toy car.

The mass of the car is 420 g.
The car travels at constant speed, a distance of 2.4 m, up a slope in a time of 3.5 s.

The slope is shown in Fig. 7.1.

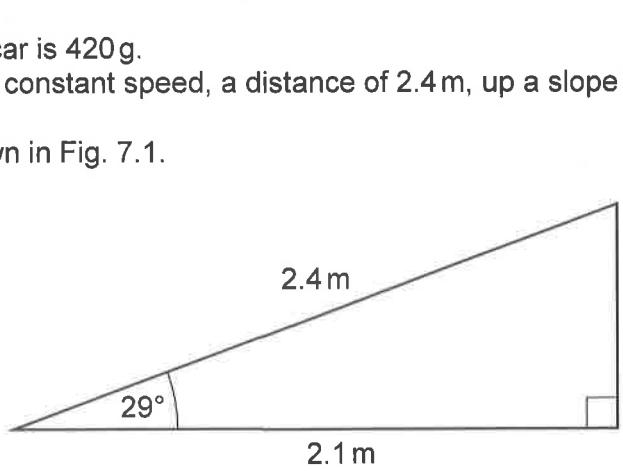

Fig. 7.1

(i) Show that the work done per unit time by the toy car is 1.4 W.

[3]

(ii) The motor of the toy car needs to produce a power greater than 1.4 W to travel up the slope at constant speed.

Suggest why this is the case and what happens to the extra power.

.....

.....

..... [2]

(b) The same toy car as described in **(a)** is driven at a different constant speed in a straight line along a horizontal track.

(i) Explain how to determine the speed of the car using simple laboratory equipment.

.....

.....

.....

..... [3]

(ii) The speed of the car is determined to be $0.82\,m\,s^{-1}$.

Calculate the kinetic energy of the car.

kinetic energy = ... J [1]

(iii) Assume that the power output of the car is 1.5 W.

Calculate the average driving force of the car.

force = ... N [3]

(iv) Deduce the average resistive force on the car. Explain your answer.

.....

.....

..... [2]

(c) (i) The drag force D acting on a car depends on the area of the front of the car A, the density of the air ρ and the velocity of the car v:

$$D \propto A^x \rho^y v^z$$

where x, y, z are integers.

The constant of proportionality is dimensionless.

Use SI base units to:
- show that $z = 2$ and
- determine the values of x, y.

$x =$ .....

$y =$ .....

[3]

(ii) A new toy car has 5 different power settings. Each setting drives the car at a different constant velocity along the same track.
The power output of the car at each velocity is known.

The total resistive force is the sum of the frictional force and drag force.
The frictional force acting on the car is independent of the velocity of the car.

Explain how the measurements of velocity and power can be used, together with a suitable graph, to determine the frictional force on the car.

.....

.....

.....

..... [3]

[Total: 20]