6.2 Work done

# Aims:

*(b)* show an understanding of the concept of work in terms of the product of a force and is placement in the direction of the force

# Work done in raising a weight using a ramp

Set up the apparatus as shown in the diagram.

Lab bench

Lab bench

Variable mass

String

Slope

Wooden block

Retort stand and bosses

Pulley

* Measure and record the mass of the wooden block.
* Mark the position of the wooden block at the bottom of the slope.
* Carefully add mass to the end of the string until the wooden block *just* starts to move. Experiment until you are happy that the block is just moving up the slope. Record the pulling mass.
* When the block comes to a rest (usually because the pulling mass has hit the floor) measure how far the block has moved along the slope.
* Calculate the work done in pulling the block up the slope.
* Measure how high the wooden block has been raised (i.e. the vertical distance moved). Think carefully how you might do this accurately.
* Calculate the gravitational potential energy gained by the block.
* Compare the work done by the falling variable mass to the GPE gained. What do you notice? Can you explain this?

Calculate the efficiency of the ramp system in lifting the weight:

efficiency = potential energy gained × 100%

work done

Analysis of forces on the block:



F

N

* Copy the diagram above and add the frictional force.
* At equilibrium, when the block is moving up the slope with constant velocity:

magnitude of force *F* = magnitude of frictional force + component of *W* acting down the slope

Use this relationship to estimate the frictional force acting down the slope.

* Calculate the work done *against friction* in pulling the block up the slope.
* If the block is pulled very slowly up the ramp the expression:

**Potential energy gained + work done against friction = total work done**

is reasonably accurate.

Test this expression using your results and suggest a reason for any discrepancies.

# Results and Calculations

# Along the flat and up the hill

Think carefully, and calculate a little.

Two speeds, one principle.

Travelling slowly, at about 5 miles an hour, the retarding forces acting on a cyclist are about 5 N.

1. What propulsive force must the cyclist provide to travel at constant speed?

2. How much energy does the cyclist have to provide to cover 5 m?

At a higher speed, nearly 10 mph the retarding forces are much larger, nearly 8 N.

3. Write down the propulsive force required at this speed.

4. Calculate the energy the cyclist must provide every to cover 5 m at this constant speed.

Climbing a hill at a steady speed of 5 mph the cyclist finds herself perspiring rather more than on the flat. The mass of the cycle plus cyclist is 80 kg. The ergometer pedals fitted report the energy supplied to the bicycle as 185 J to cover a 5 m stretch of road.

5. How much energy is used to lift the cyclist uphill?

6. How much height does she gain in travelling along the 5 m stretch of road?

7. How much energy would she have to provide to cover this same stretch of road at 10 mph?

8. What is the retarding force acting on her, when travelling uphill at 10 mph?

9. Draw a vector diagram for the retarding forces (due to drag and gravity) acting on her at 10 mph.

10. Calculate the retarding force due to the slope as a fraction of her weight. Comment on the advantages of using the slope of the hill rather than lifting bike and rider vertically by the same distance