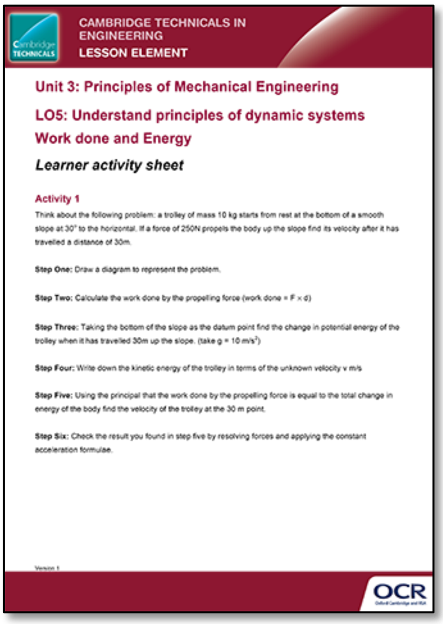
Unit 3: Principles of Mechanical Engineering

LO5: Understand principles of dynamic systems

Work done and Energy

Instructions and answers for teachers

These instructions should accompany the OCR resource 'Understand principles of dynamic systems – Work done and Energy' *activity which supports Cambridge Technicals in Engineering Level 3.*



CAMBRIDGE TECHNICALS IN ENGINEERING
LESSON ELEMENT

Unit 3: Principles of Mechanical Engineering

LO5: Understand principles of dynamic systems

Work done and Energy

Learner activity sheet

Activity 1

Think about the following problem: a trolley of mass 10 kg starts from rest at the bottom of a smooth slope at 30° to the horizontal. If a force of 250N propels the body up the slope find its velocity after it has travelled a distance of 30m.

Step One: Draw a diagram to represent the problem.

Step Two: Calculate the work done by the propelling force (work done = F × d)

Step Three: Taking the bottom of the slope as the datum point find the change in potential energy of the trolley when it has travelled 30m up the slope. (take g = 10 m/s²)

Step Four: Write down the kinetic energy of the trolley in terms of the unknown velocity v m/s

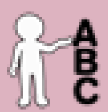
Step Five: Using the principal that the work done by the propelling force is equal to the total change in energy of the body find the velocity of the trolley at the 30 m point.

Step Six: Check the result you found in step five by resolving forces and applying the constant acceleration formulae.

Version 1

The Activity:

What follows is a general proof of the equivalence of 'work done' and the 'change of energy'. This often gives an alternative, sometimes simpler, method of solving problems of dynamics.



This activity offers an opportunity for English skills development.

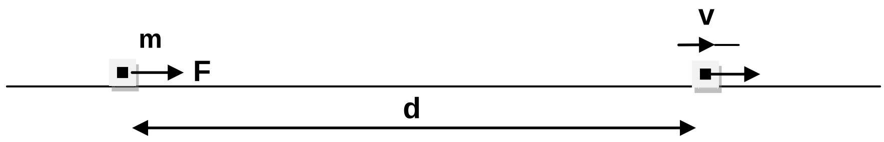
This activity offers an opportunity for maths skills development.

Suggested timings:

Activity 1 30 minutes

Activity 1

Imagine a body of mass **m** acted on by a force **F** as shown in fig below. It is sitting on a smooth surface and starts from rest reaching a velocity **v** after travelling a distance **d.**



The work done by the force acting on the body is defined as $\mathbf{W} = \mathbf{F} \times \mathbf{d}$

Newton's second law gives $\mathbf{F} = \mathbf{m} \times \mathbf{a}$ so rearranging this gives $\mathbf{a} = (\mathbf{F}/\mathbf{m})$

Applying the constant acceleration formula $v^2 - u^2 = 2as$ gives the final velocity:

As the body starts from rest u=0 and d is the distance travelled, i.e. s=d

$$\mathbf{v}^2 = 2 \times (\mathbf{F}/\mathbf{m}) \times \mathbf{d}$$

So the final KE (which, because the body was initially at rest is the change in KE):

$$KE = 1/2 \times \mathbf{m} \times \mathbf{v}^2$$

$$KE = 1/2 \times \mathbf{m} \times 2 \times (\mathbf{F}/\mathbf{m}) \times \mathbf{d}$$

$$= (\mathbf{F} \times \mathbf{d})$$

QED.

This can be a useful method for solving many problems in dynamics. The principal that the work done by a force acting on a body is equal to the total change in energy of the body is always true, even when the body changes both kinetic and potential energy.

Answer is 34.64 m/s

A typical application of this method is given in Task 1.

Learners may need support through the stages set out in the learner task.

Step Two: the work done by the force = $F \times d$

= 250x30

= 7500 J

Step Three: increase in GPE by the body after travelling 30m

= $m \times g \times h$

= $10 \times 10 \times 30\sin 30$ (taking $g=10m/s^2$)

= 1500J

Step Four: kinetic energy of the body= 1/2 $m \times v^2$

= $5v^2$J

Step Five: As the work done by the force pushing the body up the slope is equal to the total change in energy of the body it follows that

Work done by force = Increase in KE + Increase in GPE

7500 = $1500 + 5v^2$

v = 34.6 m/s

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