



AS Level Physics

Chapter 2 – Mechanics

2.6.2 Work and Conservation of Energy

Worked Examples

WORK DONE EXAMPLES

Exam Style Question 1:

- Define work done by a force.
- A crate is pushed along a rough horizontal surface at a constant speed. State what happens to the work done on the crate.
- Fig. 6.1 shows an electric crane lifting a mechanical digger.

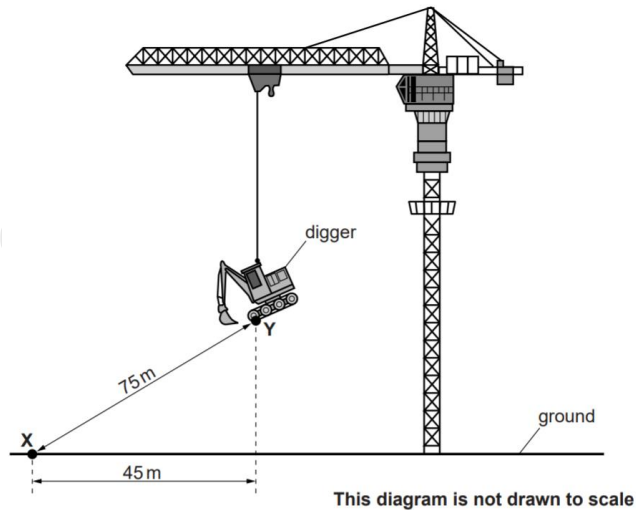


Fig. 6.1

The mass of the digger is 5200 kg . The crane takes 1.5 minutes to lift the digger from X to Y.

Calculate the rate of work done to lift the digger from X to Y.



WORK DONE EXAMPLES

Exam Style Question 1:

Answer:

- Define work done by a force.**

Work done = force \times distance moved in the direction of the force.

- State what happens to the work done on the crate when pushed through a rough surface.**

Work done against friction generates heat.

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WORK DONE EXAMPLES

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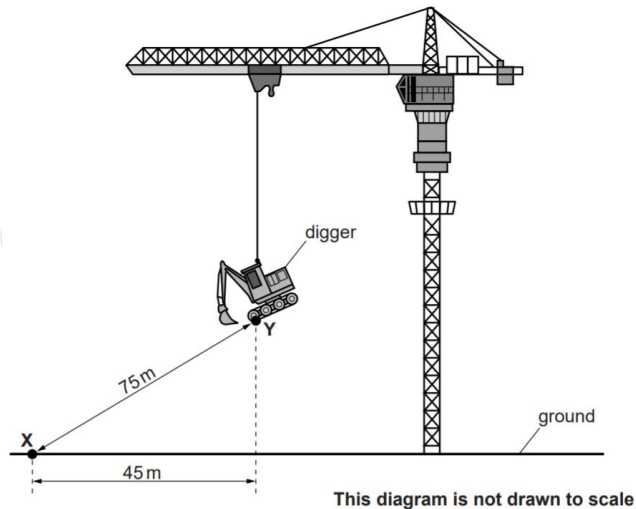


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WORK DONE EXAMPLES

Exam Style Question 1:

Answer:

c) Calculate the rate of work done to lift the digger from X to Y.

Remember the force the crane is applying on the digger is acting vertically and so the distance moved in the direction of the force is the vertical distance. Unfortunately, the question hasn't given us that distance.

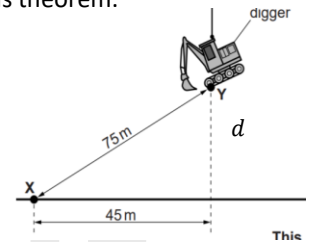
Step 1: Calculate the vertical distance using Pythagoras theorem.

As this is a right-angle triangle you can use $a^2 + b^2 =$

Therefore:

$$\begin{aligned}d^2 + 45^2 &= 75^2 \\d &= \sqrt{75^2 - 45^2} \\d &= 60 \text{ m}\end{aligned}$$

So, the vertical distance is 60m.



Step 2: Calculate the work done.

The digger has a mass of 5200 kg so the crane has to apply enough force to lift the mass of the digger.

To calculate the force the crane applies to the digger to lift it, you have to times the mass of the digger by 9.81 m s^{-2} to calculate the diggers weight. Then we can use this force along with the vertical distance we calculated to work out the work done by the crane to lift the digger.

$$\begin{aligned}\text{Work done} &= F \times d \\ \text{Work done} &= (5200 \text{ kg} \times 9.81 \text{ m s}^{-2}) \times 60 \text{ m} \\ \text{Work done} &= 3.06 \times 10^6 \text{ J}\end{aligned}$$



WORK DONE EXAMPLES

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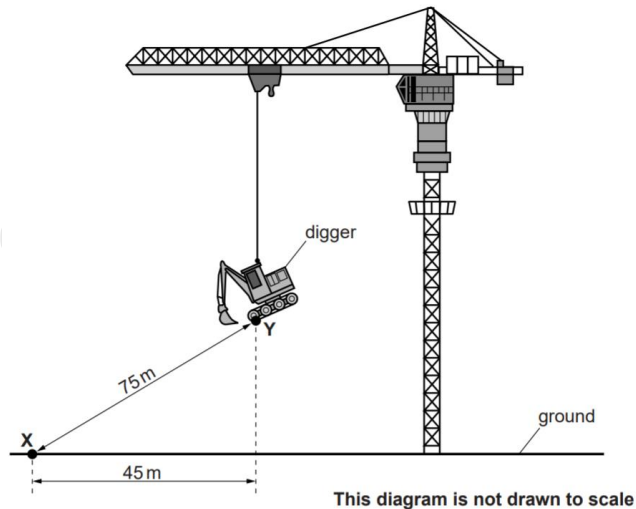


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Calculate the rate of work done to lift the digger from X to Y.



WORK DONE EXAMPLES

Exam Style Question 1:

Answer:

- Calculate the rate of work done to lift the digger from X to Y.

Step 3: Calculate the rate of work done to lift the digger from X to Y. Whenever a question uses the term 'rate of' just means anything that happens per second. This is calculated by dividing the value by the time.

In this case we need the rate of work done, therefore you divide the work done by the time the crane takes to lift the digger. This will give us the work done per second or rate of work done in J s^{-1} .

In this case it takes 1.5 minutes to lift the digger from X to Y. So:

$$\begin{aligned} \text{rate of work done} &= \frac{\text{work done}}{\text{time (in seconds)}} = \frac{3.06 \times 10^6 \text{ J}}{1.5 \text{ mins} \times 60 \text{ seconds}} \\ \text{rate of work done} &= \frac{3.06 \times 10^6 \text{ J}}{90 \text{ seconds}} \\ \text{rate of work done} &= 3.4 \times 10^4 \text{ J s}^{-1} \end{aligned}$$

WORK DONE EXAMPLES

Exam Style Question 2:

- a) Define a vector quantity and give one example
- b) Fig 3.1. shows a force F at an angle of 30° to the horizontal direction.



Fig. 3.1

- i) The horizontal component of the force F is 7.0 N . Calculate the magnitude of the force F .
- ii) The force F moves an object in the horizontal direction. In a time of 4.2 s , the object moves a horizontal distance of 5.0 m . Calculate
- 1) The work done by the force,
 - 2) The rate of work done by the force.

WORK DONE EXAMPLES

Exam Style Question 2:

Answer:

a) Define a vector and give one example

A vector is a quantity that has a magnitude and a direction.

Example: Displacement, velocity, weight, etc...

b) Calculate the magnitude of the force F .

Step 1: Redraw the diagram with the horizontal component:

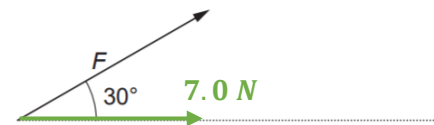


Fig. 3.1

Step 2: Use trigonometry to find the magnitude of the force F :

$$\cos 30 = \frac{7}{F}$$
$$\therefore F = \frac{7}{\cos 30}$$
$$F = 8.08\text{ N}$$

bii) 1) Calculate the work done by the force:

$$\text{work done} = F \times x$$

As the object is moved in the horizontal direction we need to use the horizontal force which is 7.0 N :

$$\text{work done} = 7.0\text{ N} \times 5.0\text{ m}$$

$$\therefore \text{work done} = 35\text{ J}$$

bii) 2) Calculate the rate of work done by the force:

$$\text{Rate of work done} = \frac{\text{work done}}{\text{time the work is being done for}}$$

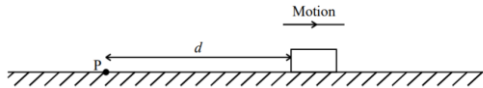
$$\text{Rate of work done} = \frac{35\text{ J}}{4.2\text{ s}} = 8.3\text{ J s}^{-1}$$

J s^{-1} is also known as Watts (W) therefore: Rate of work done = 8.3 W .

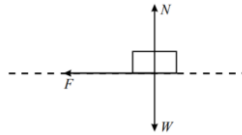
WORK DONE EXAMPLES

Exam Style Question 3:

A block is projected from a point P across a rough, horizontal surface.



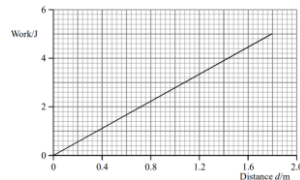
The block slows down under the influence of a constant frictional force F and eventually comes to rest. Below is a free-body diagram for the block whilst it is moving.



- a) State, with a reason, the amount of work done by each of the forces W and N as the block moves across the surface.

The sliding block does work against friction. The graph shows how the total work done varies with the distance d which the block has travelled from the projection point P .

- b) Use the graph to determine the force F .



WORK DONE EXAMPLES

Exam Style Question 3:

Answer:

- a) State the amount of work done by W and N as the block moves across the surface.

Each force does zero work because they act perpendicular to the motion of the block.

- b) Use the graph to determine the force F .

This graph is related by $W = F \times d$

Therefore: $F = \frac{W}{d}$

So, you can calculate the F by simply calculating the gradient of the graph.

To calculate the gradient, you do:

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$
$$m = \frac{5 \text{ J} - 0 \text{ J}}{1.8 \text{ m} - 0 \text{ m}} = 2.8$$

Therefore, the force, F is 2.8 N

Please see '**2.6.1 Work and Conservation of Energy notes**' pack for revision notes.

For more revision notes, tutorials, worked examples and more help visit www.tutorpacks.co.uk.

