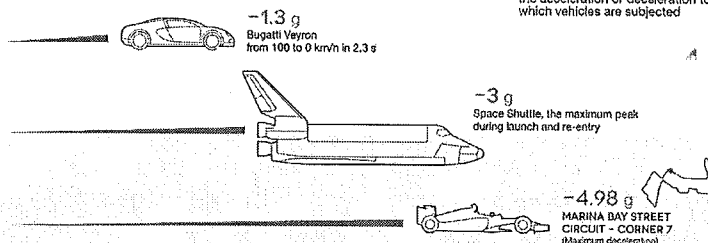


Lesson 2: Work and Power

What is work?

Work is done whenever a force makes something move. Work is measured in joules (J).

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Work (J) is calculated by finding the product between the applied force (N) and the distance moved (m).

$$\text{Work} = \text{force (N)} \times \text{distance (m)}$$

$$W = F \times d$$

The force must be parallel to the distance moved otherwise no work is done.

If no distance is moved then no work is done.

Example: How much work is done by a boy pushing a car with a force of 800N for a distance of 200m?

$$\begin{aligned} W &= F \times d \\ W &= 800 \text{ N} \times 200\text{m} \\ W &= 160000 \text{ Nm} \\ &160000 \text{ J} \end{aligned}$$

Additional Practice

1. Work is done whenever a force makes an object move.

2. Calculate the work done by a 100N force applied to a 10kg object and the object moves a distance of 10 m.

$$\begin{aligned} W &= F \times d \\ &= 100\text{N} \times 10\text{m} \\ &= 1000 \text{ Nm or J} \end{aligned}$$

3. If 20J of work is done on a 5 kg object moving it a distance of 20m, what is the applied force on the object?

$$W = F \times d \quad F = \frac{W}{d} = \frac{20 \text{ J}}{20 \text{ m}} = 1 \text{ N}$$

4. A 200N force moves a 15kg object and as a result does 5000J of work on the object. What distance does the object move as a result of the work done on it?

$$W = F \times d \quad \frac{W}{d} = F \quad \frac{5000 \text{ J}}{200 \text{ N}} = 25 \text{ m}$$

5. A 10kg object is lifted a distance of 3 m. How much work was done on the object? (the acceleration due to gravity is 9.8m/s^2)

$$F = mg = 10\text{kg} \times 9.8\text{N/kg} = 98\text{N}$$
$$W = F \times d$$
$$= 98\text{N} \times 3\text{m}$$

$$= 294\text{ Nm or J}$$

6. How much energy did the object gain?

$$294\text{ J}$$

7. Calculate the work done when a student exerts a force of 400N to push a stalled motorcycle from a busy highway to a quiet street, a distance of 500m. There is a 200N friction force acting on the motorcycle.

$$W = F \times d$$
$$= 400\text{N} \times 500\text{m}$$
$$= 200,000\text{ J}$$

↑
It is assumed that this is part of the 400N required to move the bike

8. A Physiotherapist exerts 18N of force to move a patient's arm a distance of 0.6m. Calculate the work done on the arm.

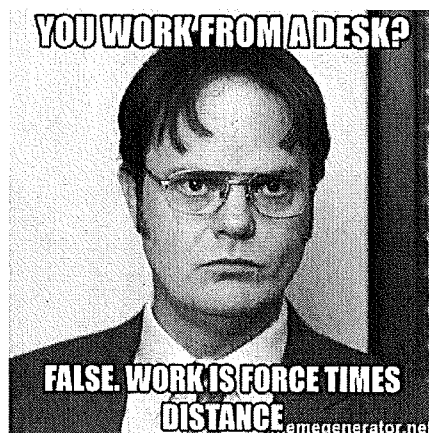
$$W = F \times d$$
$$= 18\text{N} \times 0.6\text{m} = 10.8\text{ J}$$

9. A 100W immersion heater is used to warm water in a beaker for 3.0 minutes. How much energy is transferred to the water?

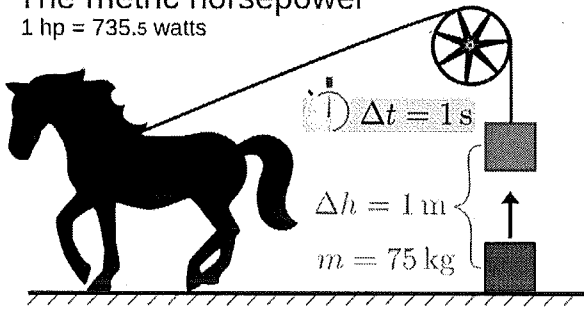
$$P = \frac{W}{t}$$

$$W = P \times t$$
$$= 100\text{W} \times (3.0\text{min} \times \frac{60\text{s}}{\text{min}})$$

$$= 18,000\text{ J}$$



The metric horsepower
1 hp = 735.5 watts



What is Power?

Power is the rate at which work is done.

Power = work/time

$$P = W / t$$

Power is measured in watts (W), which is a joule per second.

Example: What is the power of a bulldozer that does 5.5×10^4 J of work in 1.1s?

$$P = W / t$$

$$P = 5.5 \times 10^4 \text{ J} / 1.1 \text{ s}$$

$$P = 5.0 \times 10^4 \text{ W}$$

1. Complete the following table.

| | Variable used | Units measure in | Unit symbol |
|-------|---------------|------------------|-------------|
| Power | P | watts | w |
| Work | W | Joules | J |
| Time | t | Seconds | s |

2. A water pump does 250 000 Joules of work to remove water from a swimming pool in one hour (3600 seconds). Determine the power rating of the pump.

$$P = \frac{W}{t} = \frac{250,000 \text{ J}}{3600 \text{ s}} = 69.4 \text{ W}$$

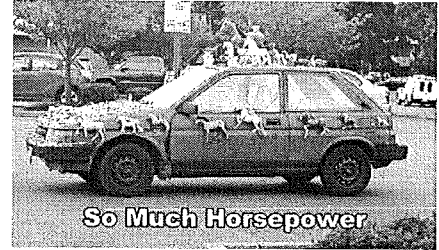
3. A winch lifts a 12 kg rock vertically upward from a height of 1.0 metre to 12 metres in 15 seconds.

a) Determine the work done by the winch.

$$\begin{aligned} W &= F \times d &= 1294 \text{ J} \\ &= (m \times g) \times d \\ &= (12 \times 9.8) \times 11 \text{ m} \end{aligned}$$

b) Determine the power rating of the winch.

$$P = \frac{W}{t} = \frac{1294 \text{ J}}{15 \text{ s}} = 86.2 \text{ W}$$



4. A 1200 Watt blow-dryer for 10 minutes (600 seconds). Determine the amount of energy that is used.

$$P = \frac{W}{t} \quad W = P \times t$$

$$= 1200 \text{ W} \times 600 \text{ s}$$

$$= 720,000 \text{ J}$$

5. An alkaline AA 1.5 V battery holds around 13 000 Joules. A small toy car is rated at 0.50 W. How many seconds will the toy car be able to operate continuously?

$$P = \frac{W}{t} \quad t = \frac{W}{P} = \frac{13,000 \text{ J}}{0.50 \text{ W}} = 26,000 \text{ s}$$

6. Determine the power for each of the following electrical appliances:

a) The output of a laser is 0.05J every second. $\frac{0.05 \text{ J}}{1 \text{ s}} = 0.05 \text{ W}$

b) A curling iron uses 48000 J of energy per minute. $= \frac{48000 \text{ J}}{60 \text{ s}} = 800 \text{ W}$

c) An electric light bulb uses $2.16 \times 10^5 \text{ J}$ of energy in one hour. $\frac{2.16 \times 10^5 \text{ J}}{3600 \text{ s}} = 60 \text{ W}$

7. Determine the amount of energy transformed or used in each case:

a) A 2000W electric pencil sharpener operates for 3.0s $2000 \text{ W} \times 3.0 \text{ s} = 6000 \text{ J}$

b) A 1200W kettle heats water for 5 minutes. $1200 \text{ W} \times 300 \text{ s} = 360,000 \text{ J}$

c) A 100W stereo is operated for one hour. $100 \text{ W} \times 3600 \text{ s} = 360,000 \text{ J}$