WORK AND POWER

In Physics (or mechanics), work is said to be done whenever a force is applied to cause a body to move. When you push a car a certain distance or you lift a load from the floor to a table, you are said to have done work. If you lift a bag of palm kernel from the ground on to your head, and carry the load standing on the same spot even for several hours, you have only done work by lifting the load from the ground to your head. You have done no work in carrying the bag for so long standing on the spot.

Work is said to be done whenever a force moves its point of application a distance in the direction of the force. Mathematically, work done is defined as the product of the force and the displacement/height in the direction of the force.

$$Work = Force \times Distance = F \times s$$

$$Work = Force \times Height = F \times h$$

The units of Work, Force and Distance/Height are Joules (J), Newton (N), and metres (m) respectively.

Power

If two boys of the same weight climb a flight of steps of the same height, the boy that gets to the top first is said to have greater power. This is because he has done the work of moving his weight through that height at a shorter time. If the work W is done in time t, then the power is given as:

$$Power = \frac{work}{time}$$

If the work is in Joules and the time is in seconds, then the power is measured in Watts.

$$1\ watt = 1 joule\ per\ second$$

Other commonly used units of power are the kilowatt (kW), the megawatt (MW) and the horsepower (hp).

$$1kW = 1000W = 10^3 W$$

$$1MW = 1000kW = 10^3 \times 10^3 W = 10^6 W$$

$$1hp = 746W$$

Calculations concerning Work and Power

1. A man of mass 50kg ascends a flight of stairs 5m high in 5seconds. If acceleration due to gravity is $10ms^{-2}$, what is the power expended?

Solving

Mass = 50kg; h = 5m; t = 5s; g = $10ms^{-2}$

W = F × s = mgh = 50 × 10 × 5 = 2500J

$$P = \frac{W}{t} = \frac{2500}{5} = \mathbf{500W}$$

2. A boy weighing 350N runs up a flight of stairs consisting of 20 steps each 10cm high in 10 seconds. What is his power?

Solving

Weight (or F) = 350N; h = 20 × 10cm = 200cm = 2m; t = 10s

$$Power = \frac{Work}{time} = \frac{F \times h}{t} = \frac{350 \times 2}{10} = \frac{700}{10} = \mathbf{70W}$$

3. A body is displaced through a certain distance x by a force of 30N. If the work done is 100J and the displacement is in the direction of force, what is the value of x?

Solving

F=30N; W=100J; x =?

$$W = F.x \rightarrow x = \frac{W}{F} = \frac{100}{30} = \mathbf{3.33}\boldsymbol{m}$$

4. Find the electrical energy expended by an electric lamp labelled 100W in 8 seconds.

Solving

$$P = \frac{W}{t} = \frac{100}{8} = \mathbf{12.5}\boldsymbol{W}$$

5. A student eats a dinner containing 8.0×10^6J of energy. He wishes to do an equivalent amount of work in a nearby gym by lifting a 60kg object. How many times must he raise the object to expend this much energy? Assume that he raises it a distance of 2.0m each time.

Solving

Energy obtained=8.0×10^6J

Energy to expend (or work to do) = F×s

Force (or weight) = mg = 60 × 10 = 600N

$$s = \frac{E}{F} = \frac{8.0 \times 10^6}{600} = 1.33 \times 10^4 m$$

$s = h \times x$ (x is the number of times the weight would be lifted through the height)

$1.333 \times 10^4 = 2 \times x$

$x = \frac{1.333\times10^4}{2} = 0.6667 \times 10^4$

$\boldsymbol{x = 6.67 \times 10^3\ times}$

∴ He would have to lift the 60kg weight about 6,667 times to expend all of the energy.