

# L01 - Work and Energy

**Force:** Push or pull applied to an object; measured in newtons. (*Imperial → Pounds*)

**Work:** A measure of the amount of energy transferred from one object to another when an object moves against an opposing force or the speed of an object increases.

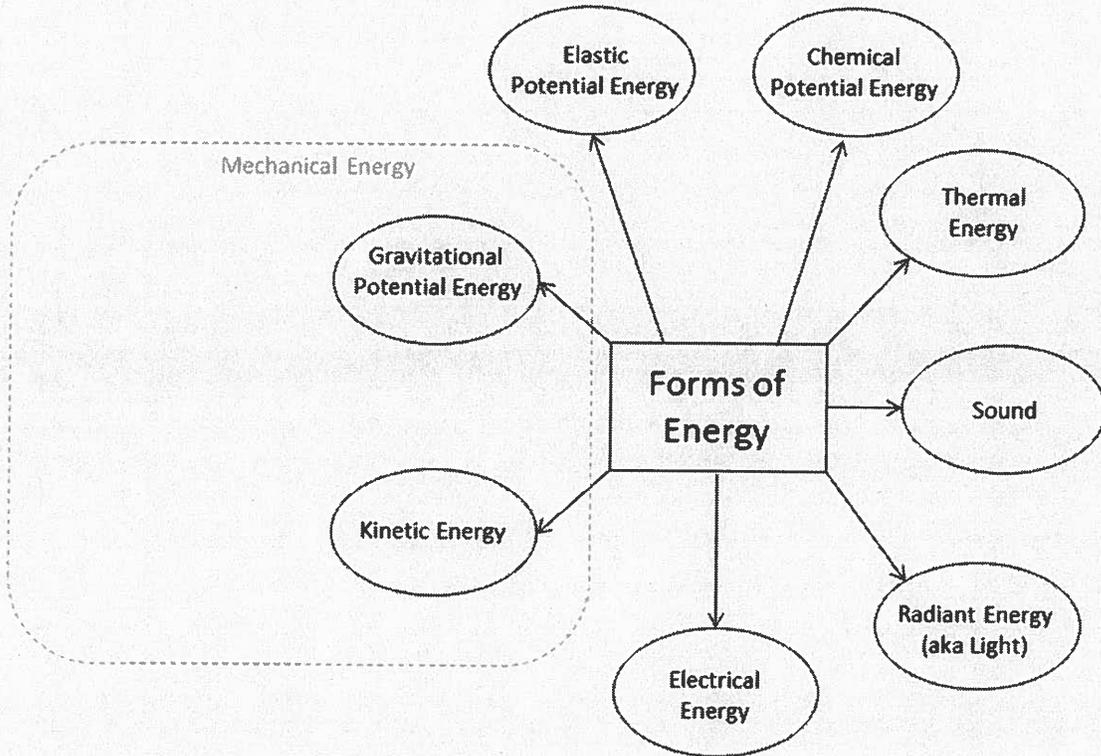
Energy is required to do work.

Q1: Is it a Scalar or Vector?

Yes   No   Both   Checked  
4   9   1   1

Magnitude only  
No direction

Q2: What forms of Energy exist?



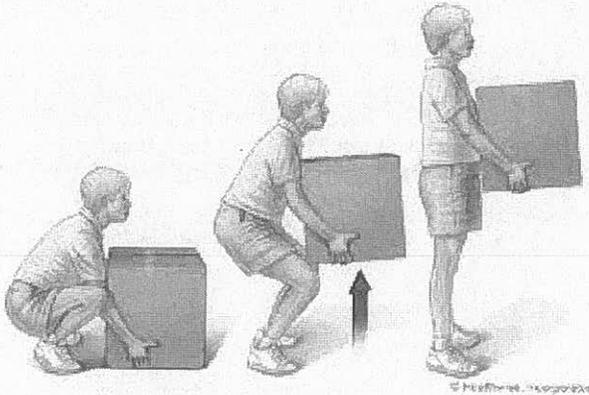
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Work in Science 10

$$W = Fd$$



In the diagram below, a child is moving a box against the opposing force of gravity.



Q3: A child lifts a 5kg box 1.2 meters above the ground. How much work did the child do?

$$F_g = mg \\ = (5)(9.81) \\ = 49.05 \text{ N}$$

$$F_{app} = 49.05 \text{ N} \\ d = 1.2 \text{ m}$$

$$W = Fd \\ = (49.05)(1.2) \\ = 58.86 \text{ J}$$

$$E_p = mgh \\ = (5)(9.81)(1.2) \\ = 58.86 \text{ J}$$

Q4: A child lifts a 10kg box 0.7 meters above the ground. How much work did the child do?

$$F_g = mg \\ = (10)(9.81) \\ = 98.1 \text{ N}$$

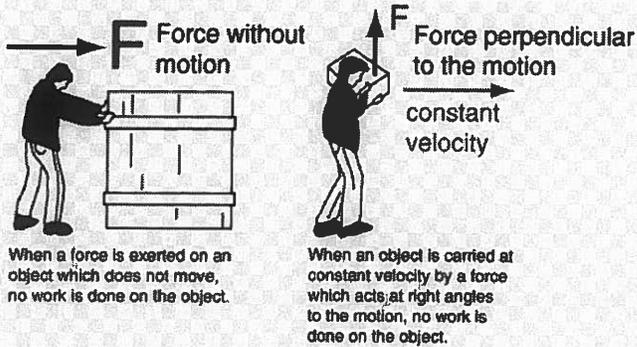
$$W = Fd \\ = (98.1)(0.7) \\ = 68.67 \text{ J}$$

Q5: While holding an 8kg box in the air, the child now walks 10 meters [North]. How much work did the child do?

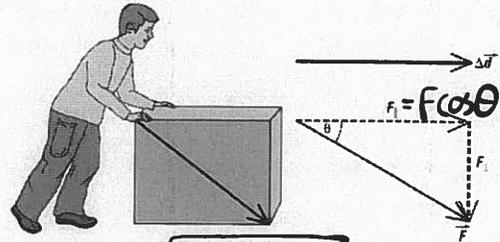
0 J  
Because  $F$ ,  $d$  are  
in different directions.

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## Work in Physics 20 per the Data Sheet



Only the component of force in the direction of motion determines how much work is done.



$$W = |\vec{F}| |\vec{d}| \cos \theta$$

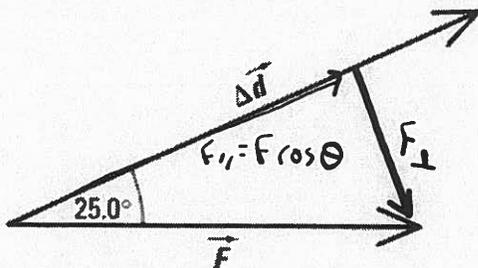
Work = Force \* Distance

Joule = Newton \* Meter

$$W = F_{\parallel} d$$

$$W = |\vec{F}| \cos \theta \cdot |\vec{d}|$$

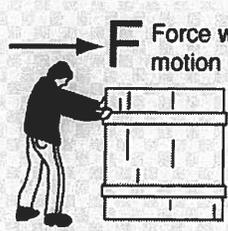
**Q6:** A force of 150 N [0°] is acting on an object that moves over a displacement of 25.0 m [25.0°] while the force acts. What is the work done by this force?



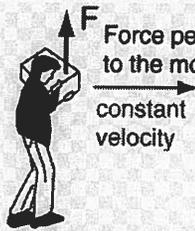
$$\begin{aligned} W &= F \cdot d \cdot \cos \theta \\ &= (150)(25) \cos 25 \\ &= 3398.65 \text{ J} \end{aligned}$$

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Work in Physics 20 per Mr. Bayer

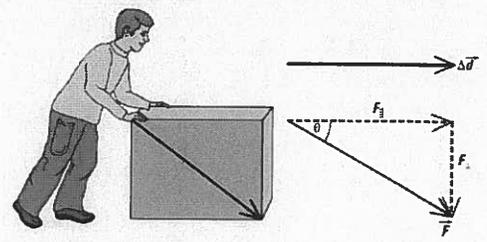


When a force is exerted on an object which does not move, no work is done on the object.



When an object is carried at constant velocity by a force which acts at right angles to the motion, no work is done on the object.

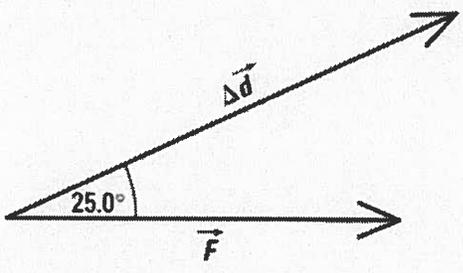
Only the component of force in the direction of motion determines how much work is done.



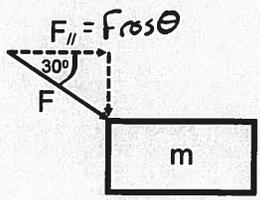
$$W = F_{\parallel} d$$

Work = Force \* Distance  
Joule = Newton \* Meter

Q7: A force of 150 N [0°] is acting on an object that moves over a displacement of 25.0 m [25.0°] while the force acts. What is the work done by this force?

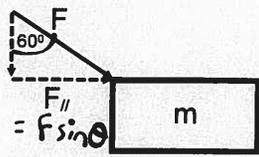


Q8: A force of 20N acts on a mass, as depicted below. The mass moves 10m horizontally. How much work is done?



$$\begin{aligned} W &= F_{\parallel} \cdot d \\ &= (F \cos \theta) \cdot d \\ &= (20 \cos 30) \cdot 10 \\ &= 173.2 \text{ J} \end{aligned}$$

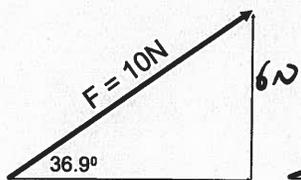
Q9: A force of 20N acts on a mass, as depicted below. The mass moves 10m horizontally. How much work is done?



$$\begin{aligned} W &= F_{\parallel} \cdot d \\ &= (F \sin \theta) \cdot d \\ &= (20 \sin 60) \cdot 10 \\ &= 173.2 \text{ J} \end{aligned}$$

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Work in University using the Dot Product



$$F \cos \theta = 8N$$

$$\vec{i} \quad \vec{j}$$

$$\vec{F} = 8\vec{i} + 6\vec{j} \text{ N}$$

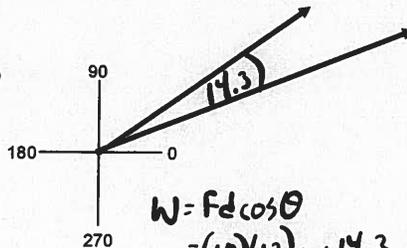
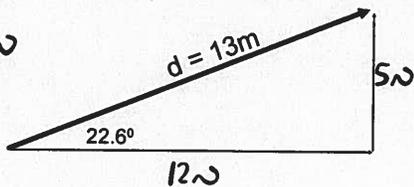
$$\vec{d} = 12\vec{i} + 5\vec{j} \text{ m}$$

$$\begin{bmatrix} 8 & 6 \end{bmatrix} \begin{bmatrix} 12 \\ 5 \end{bmatrix}$$

$$(8)(12) + (6)(5)$$

$$96 + 30$$

$$\boxed{126 \text{ J}}$$



$$W = Fd \cos \theta = (10)(13) \cos 14.3 = 126N$$

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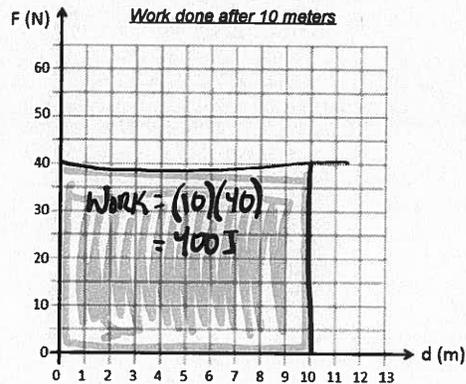
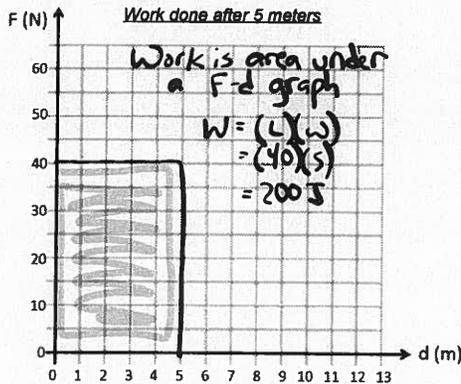
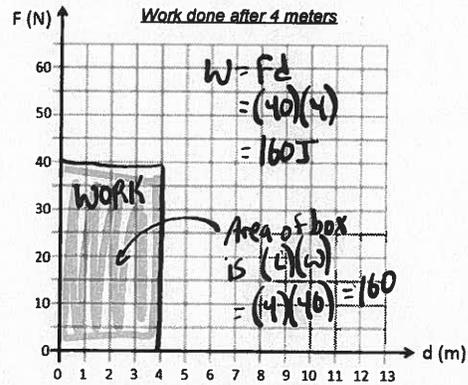
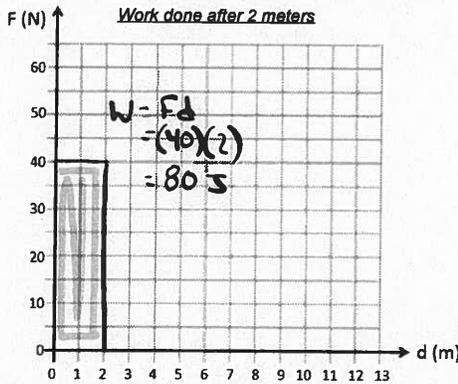
## Graphical Interpretation of Work (with Constant Force)

Q10: A cat applies 40N of force to a toy mouse to drag it 10m across a floor. How much work has the cat done? Complete the table.

Force (N)	Distance (m)	Work (J)
40	0	0
40	2	80
40	4	160
40	6	240
40	8	320
40	10	400

## Determining Work from Force-Time Graph

Q11: A cat applies 40N of force to a toy mouse to drag it 2m, 4m, 5m, then 10m across a floor. How much work has the cat done? Graph each scenario below and use the graph to calculate the work.



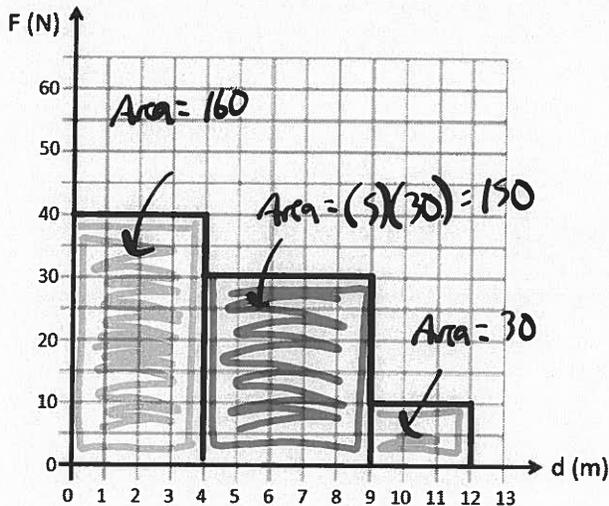
**Key Concept:** Work is the area under a Force-Distance graph



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**Graphical Interpretation of Work (with Changing Force)**

**Q12:** A cat applies a variable force to a toy mouse to drag it 12m across a floor. How much work has the cat done? Use the graph to determine the work.



What is happening in this graph?

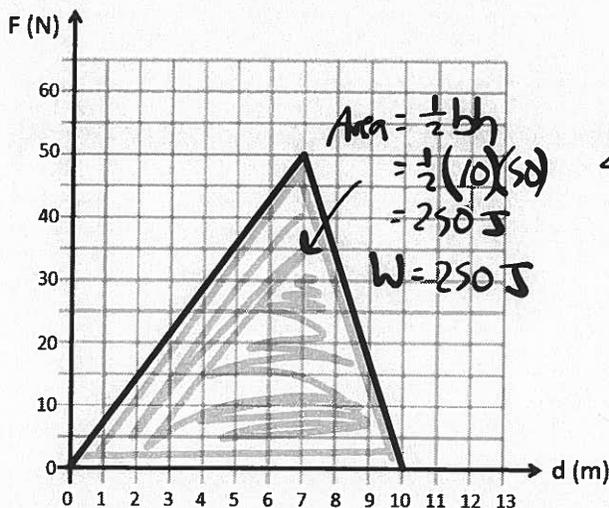
Three distinct areas.

How do we find the amount of work done?

Work is the area under a Force-Distance graph

$$\text{Work} = 160 + 150 + 30 = 340 \text{ J}$$

**Q13:** A cat applies a linearly increasing then linearly decreasing force to a toy mouse to drag it 10m across a floor. How much work has the cat done? Use the graph to determine the work.



What shapes do we see in this graph?



How do we find the amount of work done?

Work is the area under a Force-Distance graph