PHYSICS 534

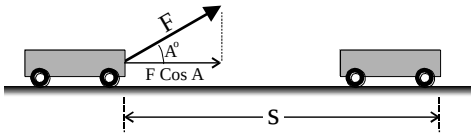
ANSWERS

EXERCISE-35 Work

RAMAN

Vankata Raman received the Nobel prize for physics in 1930 for his work on the scattering of light.

Energy is defined as the ability to do work. And, in physics, work is defined as *a force acting through a distance*. That is, work is the product of force times distance. Note that the force must be acting ***parallel*** to the distance. Thus, we have:



$W = Fs$ when **F** and **s** are parallel and $W = (F\,\text{Cos}\,A)(s)$ when **F** and **s** are not parallel

Since the unit for energy is the joule (J), and since work is energy, the unit for work is the joule (J).

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1. Define work: ***The product of force times the distance the force acts (W = Fs).***

2. Define energy: ***The ability to do work (the unit is the joule, J)***.

3. In terms of basic units (L, M and T), what are the dimensions of work?

$$W = Fs = maL = M\cdot\frac{m}{s^2}\cdot L = M\cdot\frac{L}{T^2}\cdot L = \frac{ML^2}{T^2}$$

4. A woman holds a 20 N briefcase waiting at a bus stop. How much work does she do? [0]

Since the distance the force acts is zero, the work is zero!

5. A girl pulls a wagon across a floor by means of a rope tied to the wagon. The rope makes an angle of 60º with the floor. If the tension in the rope is 75 N, how much work does she do in pulling the wagon a distance of 10 meters? [375 J]

$$W = Fs = (75\text{ N Cos }60^\circ)(10\text{ m}) = 375\text{ J}$$

Where does the energy go? ***To overcome friction (lost as heat and sound).***

6. A force of 60 N is applied to a cardboard box to pull it 15 m across a floor. The rope used to pull the box makes an angle of 46º with the floor. How much work is done? [625.2 J]

$$W = Fs = (60\ \text{N}\,\text{Cos}\,46^{o})(15\ \text{m}) = 625.2\ \text{J}$$

7. A man uses a rope to pull his 1000 kg boat 50 m along a wharf. The rope makes an angle of 60º with the horizontal. If the tension in the rope is 50 N, how much work does the man do? [1250 J]

$$W = Fs = (50\ \text{N}\,\text{Cos}\,60^{o})(50\ \text{m}) = 1250\ \text{J}$$

8. A sled that weighs 200 N is pulled a distance of 20 m by a rope making an angle of 45º with the horizontal. If the tension in the rope is 100 N, how much work is done? [1414 J]

$$W = Fs = (100\ \text{N}\,\text{Cos}\,45^{o})(20\ \text{m}) = 1414\ \text{J}$$

9. A horizontal force of 15 N is applied to a wagon. If the wagon weighs 75 N, how much work is done in moving it 0.35 km? [5250 J]

$$W = Fs = (15\ \text{N})(350\ \text{m}) = 5250\ \text{J}$$

10. A girl pulls a sled by applying a force of 40 N to a rope attached to the sled. The rope makes an angle of 60º with the ground. If she moves the sled 50 m horizontally, how much work does the girl do? [1.0×10^3 J]

$$W = Fs = (40\ \text{N}\,\text{Cos}\,60^{o})(50\ \text{m}) = 10\,000\ \text{J}$$

11. Because of friction, a force of 400 N is needed to drag a wooden box 25 m across a floor. The box was pulled by a rope making an angle of 48º with the floor.

a) What was the tension in the rope? [597.9 N]

$$\text{Cos } 48^o = \frac{400 \text{ N}}{T} \qquad T = \frac{400 \text{ N}}{\text{Cos } 48^o} = \frac{400 \text{ N}}{0.669} = 597.9 \text{ N}$$

b) How much work was done? [1.0 x 10^4 J]

$$W = Fs = (400 \text{ N})(25 \text{ m}) = 10\,000 \text{ J}$$

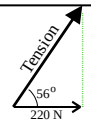
12. A horizontal force acts on an object for a distance of 12 m. If the work done on the object is 300 joules, find the force. [25 N]

$$W = Fs$$

$$F = \frac{W}{s} = \frac{300 \text{ J}}{12 \text{ m}} = 25 \text{ N}$$

13. A metal container has a mass of 80 kg. To overcome friction, it is pulled by a rope making an angle of 56º with the floor. If the horizontal component of the tension in the rope is 220 N and the container is pulled a distance of 20 m, find:

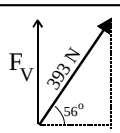
a) The tension in the rope [393 N]



Since the horizontal force is 220 N, we can find the tension in the rope.

$$\text{Cos } 56^o = \frac{220 \text{ N}}{T} \quad \text{and} \quad T = \frac{220 \text{ N}}{\text{Cos } 56^o} = \frac{220 \text{ N}}{0.559} = 393 \text{ N}$$

b) The normal force [474 N]



The magnitude of the normal force equals the total force down.

$$F_V = 393 \text{ N Sin } 56^o = 393 \text{ N} \times 0.829 = 325.6 \text{ N} = 326 \text{ N}$$

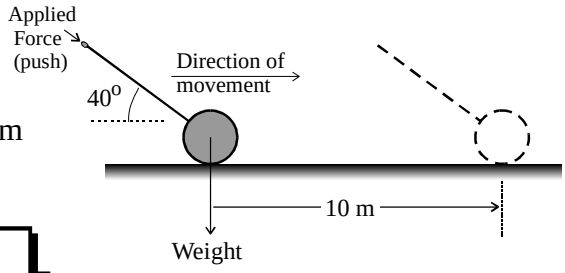
$$F_N = \text{weight} - F_V = 800 \text{ N} - 326 \text{ N} = 474 \text{ N}$$

c) The frictional force [220 N]

Since the object is pulled at constant velocity, total forces right = total forces left.

Thus, the total force towards the right (220 N) equals the frictional force left (220 N).

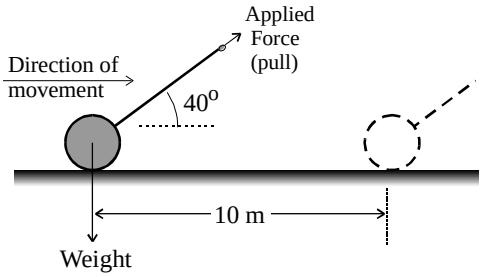
14. In flattening the ground of a tennis court, Robert uses a 20 kg roller (see diagram).



a) If Robert ***pushes*** the roller a distance of 10 m with an applied force of 200 N, how much work does he do? [1532 J]

$$W = Fs = (w\,\text{Cos}\,40^\circ)(10\text{ m})$$
$$= (200\text{ N}\,\text{Cos}\,40^\circ)(10\text{ m})$$
$$= 1532\text{ J}$$

b) If Robert ***pulls*** the roller a distance of 10 m with an applied force of 200 N, how much work does he do? [1532 J]



$$W = Fs = (w\,\text{Cos}\,40^\circ)(10\text{ m})$$
$$= (200\text{ N}\,\text{Cos}\,40^\circ)(10\text{ m})$$
$$= 1532\text{ J}$$

c) Which is ***easier***, to push or pull the roller?

It is easier to pull since in pulling, the vertical component of the pull is upward, thereby reducing the weight.

d) Which is ***more effective*** in flattening the ground, pushing or pulling the roller?

It is more effective to push since in pushing, the vertical component of the push is downward thereby increasing the weight.

15. A 5 kg cart is pushed on a horizontal frictionless surface by a force of 15 N. After traveling a distance of 3 m, the force changes to 20 N moving the wagon an additional 3 m. Find the work done on the cart. [105 J]

W_T = Work done by 15 N force + Work done by 20 N force
= (15 N)(3 m) + (20 N)(3 m) = 45 J + 60 J = 105 J

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