Fizzix 7.1-7.3: Work, Kinetic Energy, Gravitational Potential Energy

Jenna Restieri and Amy Wyle

7.1: Work

whenever work is done, energy is transferred

$W=Fd\cos\theta$

W: work

d: displacement of system

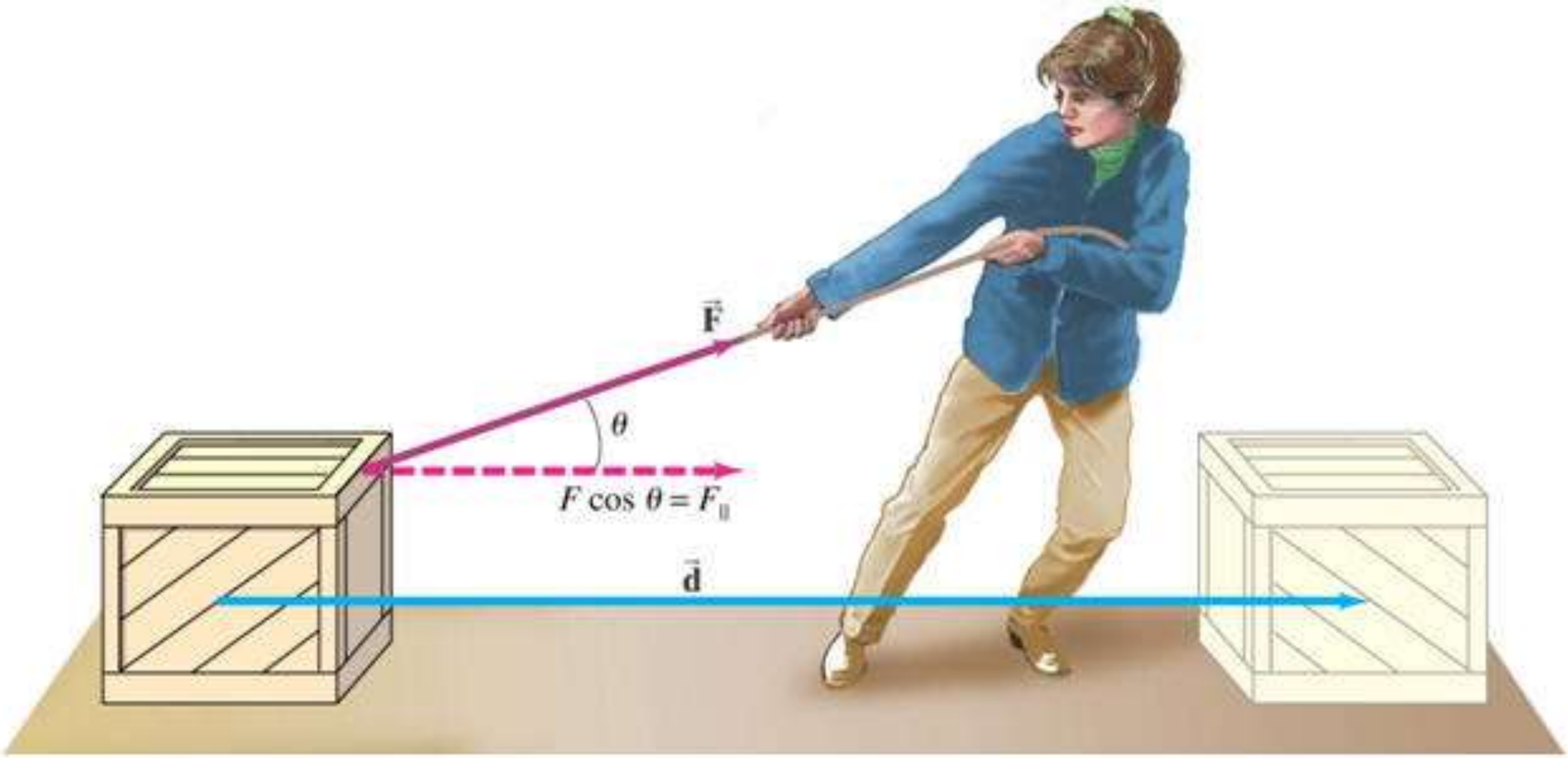
θ: angle between force vector F and displacement vector d

when θ=180, Cosθ=1, W=Fd

W is measured in Newton-Meters (joules)

Scientific Definition...

The "work" done on a system by a constant force is the product of the component of the force in the direction of motion times the distance through which force acts.



$\vec{F}$
θ
$F \cos\theta = F_{||}$
$\vec{d}$

LAB!!!

1. Pick up a pencil.
2. Turn around in your chair.
3. Measure d, F, and θ.
4. Calculate the work done on your pencil using the given formulas.

NO WORK DONE!

7.2: Kinetic Energy and the Work-Energy Theorem

<u>net work</u> - work done by external force (F_{net})

$W_{net}= F_{net}\ d \cos \theta$

$W_{net}= m\ a\ d$ $\frac{v^2-v_0^2}{2d}$

$W_{net}= m\ (\qquad)\ d$

$W_{net}=$ ½ mv^2-½ mv1^2

KE=½ mv^2

Kinetic Energy

Kinetic Energy is a form of energy associated with the motion of a particle, single body, or system of objects moving together

7.3: Gravitational Potential Energy

- everyday work is different from scientific work
- climbing stairs or lifting objects is both everyday and scientific work
  - done against the gravitational force
- when the force does positive work, it increases the gravitational potential energy

Potential vs. Kinetic Energy

if a mass is released, gravitational Force will do an amount of work "mgh," increasing kinetic energy by that same amount

PEg → Δ KE

PEg = mgh

Δ applies to any path with change of height "h"

any change in vertical position "h" of mass "m" is accompanied by PEg of mgh

More 7.3

work done in lifting an object of mass “m” through height “h”

when lifted straight up at a constant speed...

$F=mg$

$W=Fd=mgh$

Conceptual Questions

7.1 Work: The Scientific Definition

1. Give an example of something we think of as work in everyday circumstances that is not work in the scientific sense. Is energy transferred or changed in form in your example? If so, explain how this is accomplished without doing work.

2. Give an example of a situation in which there is a force and a displacement, but the force does no work. Explain why it does no work.

3. Describe a situation in which a force is exerted for a long time but does no work. Explain.

7.2 Kinetic Energy and the Work-Energy Theorem

4. The person in Figure 7.33 does work on the lawn mower. Under what conditions would the mower gain energy? Under what conditions would it lose energy?

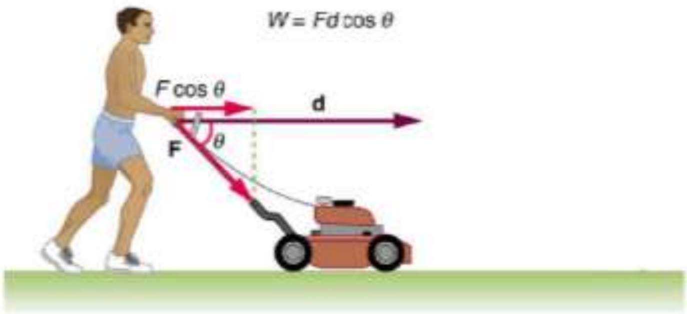


Figure 7.33

5. Work done on a system puts energy into it. Work done by a system removes energy from it. Give an example for each statement.

6. When solving for speed in Example 7.4, we kept only the positive root. Why?

7.3 Gravitational Potential Energy

7. In Example 7.7, we calculated the final speed of a roller coaster that descended 20 m in height and had an initial speed of 5 m/s downhill. Suppose the roller coaster had had an initial speed of 5 m/s *uphill* instead, and it coasted uphill, stopped, and then rolled back down to a final point 20 m below the start. We would find in that case that it had the same final speed. Explain in terms of conservation of energy.

8. Does the work you do on a book when you lift it onto a shelf depend on the path taken? On the time taken? On the height of the shelf? On the mass of the book?

Problems & Exercises

7.1 Work: The Scientific Definition

1. How much work does a supermarket checkout attendant do on a can of soup he pushes 0.600 m horizontally with a force of 5.00 N? Express your answer in joules and kilocalories.

2. A 75.0-kg person climbs stairs, gaining 2.50 meters in height. Find the work done to accomplish this task.

3. (a) Calculate the work done on a 1500-kg elevator car by its cable to lift it 40.0 m at constant speed, assuming friction averages 100 N. (b) What is the work done on the lift by the gravitational force in this process? (c) What is the total work done on the lift?

4. Suppose a car travels 108 km at a speed of 30.0 m/s, and uses 2.0 gal of gasoline. Only 30% of the gasoline goes into useful work by the force that keeps the car moving at constant speed despite friction. (See Table 7.1 for the energy content of gasoline.) (a) What is the magnitude of the force exerted to keep the car moving at constant speed? (b) If the required force is directly proportional to speed, how many gallons will be used to drive 108 km at a speed of 28.0 m/s?

Figure 7.36 The boy does work on the system of the wagon and the child when he pulls them as shown.

7. A shopper pushes a grocery cart 20.0 m at constant speed on level ground, against a 35.0 N frictional force. He pushes in a direction $25.0°$ below the horizontal. (a) What is the work done on the cart by friction? (b) What is the work done on the cart by the gravitational force? (c) What is the work done on the cart by the shopper? (d) Find the force the shopper exerts, using energy considerations. (e) What is the total work done on the cart?

8. Suppose the ski patrol lowers a rescue sled and victim, having a total mass of 90.0 kg, down a $60.0°$ slope at constant speed, as shown in Figure 7.37. The coefficient of friction between the sled and the snow is 0.100. (a) How much work is done by friction as the sled moves 30.0 m along the hill? (b) How much work is done by the rope on the sled in this distance? (c) What is the work done by the gravitational force on the sled? (d) What is the total work done?

10. (a) How fast must a 3000-kg elephant move to have the same kinetic energy as a 65.0-kg sprinter running at 10.0 m/s? (b) Discuss how the larger energies needed for the movement of larger animals would relate to metabolic rates.

11. Confirm the value given for the kinetic energy of an aircraft carrier in Table 7.1. You will need to look up the definition of a nautical mile (1 knot = 1 nautical mile/h).

12. (a) Calculate the force needed to bring a 950-kg car to rest from a speed of 90.0 km/h in a distance of 120 m (a fairly typical distance for a non-panic stop). (b) Suppose instead the car hits a concrete abutment at full speed and is brought to a stop in 2.00 m. Calculate the force exerted on the car and compare it with the force found in part (a).

13. A car's bumper is designed to withstand a 4.0-km/h (1.1-m/s) collision with an immovable object without damage to the body of the car. The bumper cushions the shock by absorbing the force over a distance. Calculate the magnitude of the average force on a bumper that collapses 0.200 m while bringing a 900-kg car to rest from an initial speed of 1.1 m/s.

14. Boxing gloves are padded to lessen the force of a blow. (a) Calculate the force exerted by a boxing glove on an opponent's face, if the glove and face compress 7.50 cm during a blow in which the 7.00-kg arm and glove are brought to rest from an initial speed of 10.0 m/s. (b) Calculate the force exerted by an identical blow in the gory old days when no gloves were used and the knuckles and face would compress only 2.00

7.3 Gravitational Potential Energy

16. A hydroelectric power facility (see Figure 7.38) converts the gravitational potential energy of water behind a dam to electric energy. (a) What is the gravitational potential energy relative to the generators of a lake of volume $50.0\ \text{km}^3$ $(\text{mass} = 5.00 \times 10^{13}\ \text{kg})$, given that the lake has an average height of 40.0 m above the generators? (b) Compare this with the energy stored in a 9-megaton fusion bomb.

18. Suppose a 350-g kookaburra (a large kingfisher bird) picks up a 75-g snake and raises it 2.5 m from the ground to a branch. (a) How much work did the bird do on the snake? (b) How much work did it do to raise its own center of mass to the branch?

19. In Example 7.7, we found that the speed of a roller coaster that had descended 20.0 m was only slightly greater when it had an initial speed of 5.00 m/s than when it started from rest. This implies that $\Delta PE >> KE_i$. Confirm this statement by taking the ratio of ΔPE to KE_i. (Note that mass cancels.)

20. A 100-g toy car is propelled by a compressed spring that starts it moving. The car follows the curved track in Figure 7.39. Show that the final speed of the toy car is 0.687 m/s if its initial speed is 2.00 m/s and it