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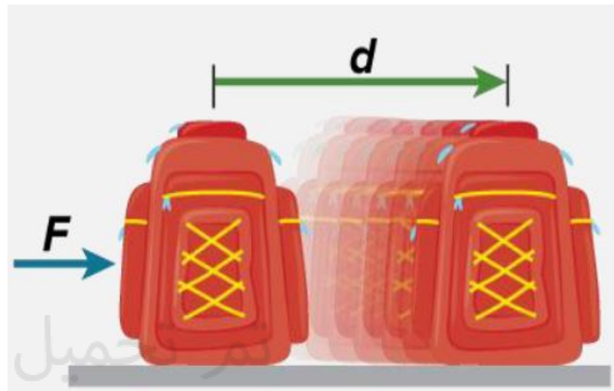
PART ONE – Multiple Choice Questions

LO – 1: Identify work as a scalar quantity measured in N.m or Joule (J). Part I– Question 1: **P188**

When a force is applied through a displacement, **work** (W) is done on the system.
Work is the transfer of energy that occurs when a force is applied through a distance; equal to the product of the system's displacement and the force applied to the system in the direction of displacement. ***W=F d***.
The SI unit of work is called a Joule (J). One joule is equal to 1 N.m. One joule of work is done when a force of 1 N acts on a system over a displacement of 1 m.

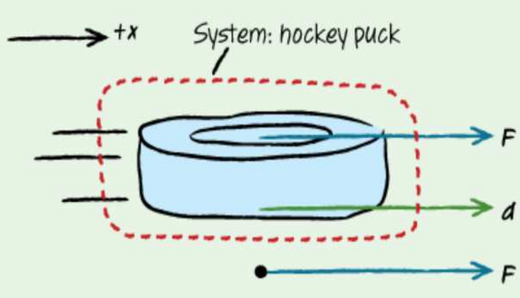


Q 1. Show that work is done when a force is applied through a displacement Page 192 Example problem 1

EXAMPLE Problem 1

WORK

A hockey player uses a stick to apply a constant 4.50-N force forward to a 105-g puck sliding on ice over a displacement of 0.150 m forward. How much work does the stick do on the puck? Assume friction is negligible.



Player does work on hockey puck

solution

2. SOLVE FOR THE UNKNOWN

Use the definition for work.

$W = Fd\cos\theta$

$= (4.50\ \text{N})(0.150\ \text{m})(\cos\theta)$ — Substitute $F = 4.50$ N, $d = 0.150$ m, $\cos\theta = \cos 0° = 1$.

$= 0.675\ \text{N·m}$

$= 0.675\ \text{J}$ — $\text{J} = 1\ \text{N·m}$

3. EVALUATE THE ANSWER

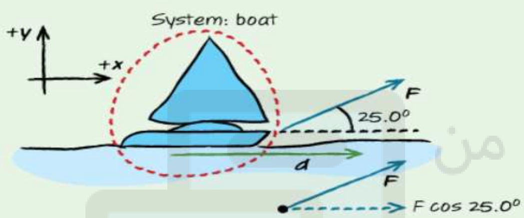
- **Are the units correct?** Work is measured in joules.
- **Does the sign make sense?** The stick (external world) does work on the puck (the system), so the sign of work should be positive.

Apply the relationship between a force F and the work done on a system by the force when the system undergoes a displacement d: W = Fd cos θ where θ is the angle between the direction of the force and the direction of displacement, and illustrate when work is positive, negative or zero with suitable examples

EXAMPLE Problem 2

FORCE AND DISPLACEMENT AT AN ANGLE

A sailor pulls a boat a distance of 30.0 m along a dock using a rope that makes a 25.0° angle with the horizontal. How much work does the rope do on the boat if its tension is 255 N?



Sailor does work on the boat.

2. SOLVE FOR THE UNKNOWN

Use the definition of work.

$$W = Fd\cos\theta$$

$$= (255\text{ N})(30.0\text{ m})(\cos 25.0°)$$ Substitute $F = 255$ N, $d = 30.0$ m, $\theta = 25.0°$.

$$= 6.93 \times 10^3\text{ J}$$

3. EVALUATE THE ANSWER

- **Are the units correct?** Work is measured in joules.
- **Does the sign make sense?** The rope does work on the boat, which agrees with a positive sign for work.

LO – 2: Define energy as the ability of a system to do work or produce a change in itself or in the
surrounding world, measured in Joules). Part I– Question 2:
Critical thinking (29). P198. Explain how to find the change in energy of a system if three agents exert forces on the system at once.

Answer:

Work = Change in Kinetic Energy. $W = \Delta K.E$ $W1 + W2 + W3 = \Delta E$

Since work is the change in kinetic energy, calculate the work done by each force. The work can be positive, negative, or zero, depending on the relative angles of the force and displacement of the object. The sum of the three works is the change in energy of the system.

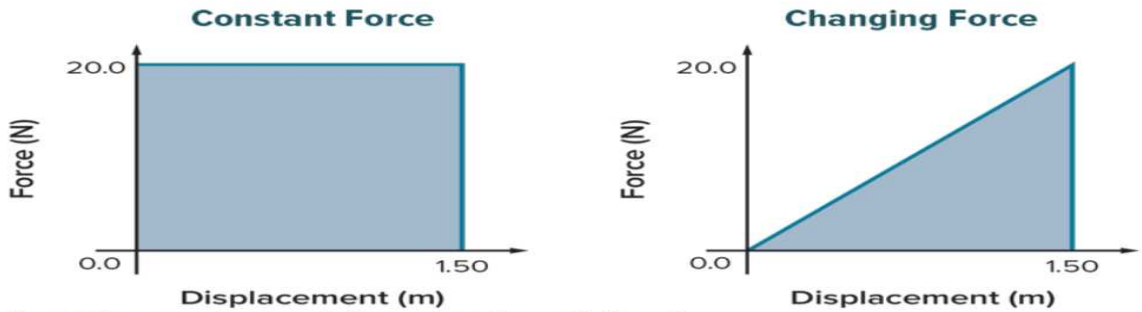


Figure 4 The area under a force-displacement graph is equal to the work.

Note that the shaded area under the left graph is also equal to (20.0 N) (1.50 m), or 30.0 J. The area under a force-displacement graph is equal to the work done by that force.

This is true even if the force changes. The right graph in **Figure 4** shows the force exerted by a spring that varies linearly from 0.0 to 20.0 N as it is compressed 1.50 m. The work done by the force that compressed the spring is the area under the graph, which is the area of a triangle, $\left(\frac{1}{2}\right)$ (base)(altitude), or

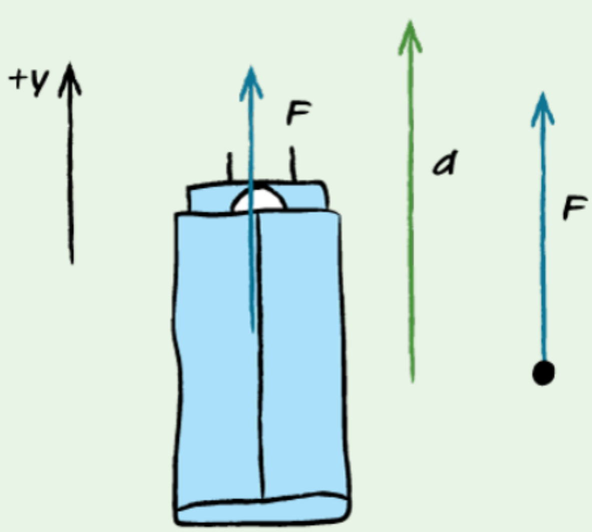
$$W = \left(\frac{1}{2}\right)(20.0\ \text{N})(1.50\ \text{m}) = 15.0\ \text{J}.$$

LO – 3: Apply the relationship between power, the work done by a force, and the time interval in which that work is done. ($P = \frac{W}{t}$) Part I– Question 3. **P196.**

EXAMPLE Problem 3

POWER

An electric motor lifts an elevator 9.00 m in 15.0 s by exerting an upward force of 1.20×10^4 N. What power does the motor produce in kW?



Known

$d = 9.00$ m

$t = 15.0$ s

$F = 1.20\times10^4$ N

Unknown

$P = ?$

2. SOLVE FOR THE UNKNOWN

Use the definition of power.

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

$$= \frac{Fd}{t}$$ Substitute $W = Fd\cos 0° = Fd$.

$$= \frac{(1.20\times10^4\ \text{N})(9.00\ \text{m})}{(15.0\ \text{s})}$$ Substitute $F = 1.20\times10^4$ N, $d = 9.00$ m, $t = 15.0$ s.

$$= 7.20\ \text{kW}$$

3. EVALUATE THE ANSWER

- **Are the units correct?** Power is measured in joules per second, or watts.
- **Does the sign make sense?** The positive sign agrees with the upward direction of the force.

Define power and specify its unit (Watt) ,and apply the relationship between power, the work done by a force, and the time interval in which that work is done (P=W/t)

17. An electric motor develops 65 kW of power as it lifts a loaded elevator 17.5 m in 35 s. How much force does the motor exert?

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

$$F = \frac{Pt}{d} = \frac{(65 \times 10^3\ \text{W})(35\ \text{s})}{17.5\ \text{m}}$$

$$= 1.3 \times 10^5\ \text{N}$$

Determine power as the product of the object's velocity (in magnitude) and the component of the force in the direction of the velocity.

26. Power An elevator lifts a total mass of 1.1×10^3 kg a distance of 40.0 m in 12.5 s. How much power does the elevator deliver?

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

$$= \frac{(1.1 \times 10^3\ \text{kg})(9.8\ \text{N/kg})(40.0\ \text{m})}{12.5\ \text{s}}$$

$$= 3.4 \times 10^4\ \text{W}$$

Practice Problem 16:
What power does a pump develop to lift 35 L of water per minute from a depth of 110 m? (One liter of water has a mass of 1.00 kg.)
Solution: $P= Wt \Longrightarrow P= mght=$ (35)(9.8)(110)60=628.83 ≈630 $watts$ ≈0.630 kW

Practice Problem 17:
An electric motor develops 65 kW of power as it lifts a loaded elevator 17.5 m in 35 s. How much force does the motor exert?
Solution: $P= Wt \Longrightarrow P= F\,dt \Longrightarrow F= (P)(t)d=$ (65000)(35)17.5=1.3×10^5 N

Practice Problem 18: CHALLENGE
A winch designed to be mounted on a truck, as shown in Figure 10, is advertised as being able to exert a 6.8×10^3 N force and to develop a power of 0.30 kW. How long would it take the truck and the winch to pull an object 15m?

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

$$t = \frac{(6.8 \times 10^3)(15)}{0.30 \times 1000}$$

$$t = 340\ s$$

$$t = 5.7\ \text{min.}$$

LO – 4: State and explain the law of conservation of energy.
Get it Question, Page 210.
The law of conservation of energy states that in a closed system, energy is not created or destroyed, but rather, is conserved.

LO – 5: Define kinetic energy and apply the relationship between a particle's kinetic energy, mass, and speed ($KE=0.5 \times m \times v^2$)

Translational kinetic energy the energy of a system due to the system's change in position.

Translational and Rotational Kinetic Energy

In the examples we have considered so far, moving objects that were changing position had kinetic energy $\left(\frac{1}{2}mv^2\right)$ due to their motion. What about energy due to an object's changing position?

Translational kinetic energy

Energy due to changing position is called **translational kinetic energy** and can be represented by the following equation.

Translational Kinetic Energy

A system's translational kinetic energy is equal to one-half times the system's mass multiplied by the system's speed squared.

$$KE_{trans} = \frac{1}{2}mv^2$$

Translational kinetic energy is proportional to the object's mass. For example, a 7.26-kg bowling ball thrown through the air has more translational kinetic energy than a 0.148-kg baseball, like the one shown in **Figure 13,** moving with the same speed.

Get it: Using the equation for translational kinetic energy, show why a car moving at 20 m/s has four times the translational kinetic energy of the same car moving at 10 m/s.

At $v = 10\ m/s$	At $v = 20\ m/s$	
$KE = 0.5\,(m)(10)^2$ $KE_1 = 50\,m$	$KE = 0.5\,(m)(20)^2$ $KE_2 = 200\ \text{m}$	$KE_2 = (4)(KE_1)$

Q 20: If the work done on an object doubles its kinetic energy, does it double its speed? If not, by what ratio does it change the speed?

Kinetic energy is proportional to the square of the velocity, so doubling the energy doubles the square of the velocity. The velocity increases by a factor of the square root of 2, or 1.4

Mathematically: $W= \Delta KE$, assume that $KE_i=0\ J$

$W1=0.5 \times m\times v1$^2 and $W2= (2)(W1)$

0.5 ×m× v2^2= (2) (0.5 ×m× v1^2)

$v2^2 = (2)(v1^2) \Rightarrow v2 = \sqrt{2}\, v1$

Question: Adult cheetahs, the fastest of the great cats, have a mass of about 70 kg and have been clocked to run at up to 32 m/s. How many joules of kinetic energy does such a swift cheetah have?

$KE = 0.5 \times m \times v^2$

$KE = 0.5 \times 70 \times 32^2 = 35840\ J.$

LO – 6: Relate the rotational kinetic energy to the object's moment of inertia and it's angular velocity: ($KE_{rot} = 0.5 \times I \times \omega^2$)

Rotational kinetic energy

If you spin a toy top in one spot, you might say that it does not have kinetic energy because the top does not change its position. However, to make the top rotate, you had to do work on it. The top has **rotational kinetic energy,** which is energy due to rotational motion.

Rotational kinetic energy can be calculated using $KE_{rot} = \frac{1}{2}I\omega^2$, where I is the object's moment of inertia and ω is the object's angular velocity.

In **Figure 14,** the diving board does work on a diver, transferring translational and rotational kinetic energy to the diver. Her center of mass moves as she leaps, so she has translational kinetic energy. She rotates about her center of mass, so she has rotational kinetic energy. When she slices into the water, she has mostly translational kinetic energy.

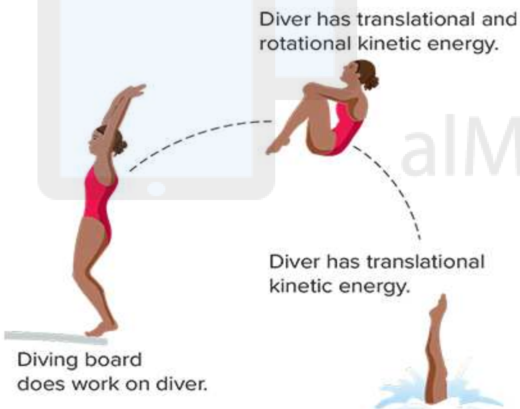


Figure 14 The diving board does work on the diver. This work increases the diver's kinetic energy.

Q 37: On a playground, some children push a merry-go round so that it turns twice as fast as it did before they pushed it. What are the relative changes in angular momentum and rotational kinetic energy of the merry-go-round?

Solution:

Angular momentum (L)	Rotational Kinetic Energy (KE_{rot})
$L = m\, r^2\, \omega$	$KE_{rot} = 0.5\ \times I \times\ \omega^2$
L will be **doubled** because it is directly proportional to the angular velocity.	KE_{rot} will be **quadrable** because it is directly proportional to the square of the angular velocity.

PART TWO – Multiple Choice Questions

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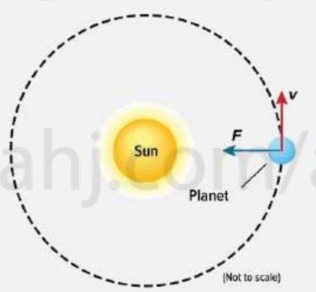
LO – 7: Recall that a perpendicular force (perpendicular to the direction of motion) does no work, but only changes the direction of motion of an object.

Calculate the work done by the force (F) shown in the figure?

Solution:	Figure (1)
Since the force (F) is **perpendicular** to the displacement, then the work done by that force is zero joule.	

LO – 8: Apply the relationship between a force F and the work done on a system by the force when the system undergoes a displacement d: ($W = Fd\ cos\ \theta$) where θ is the angle between the force and the displacement.

Q 8: A rope is used to pull a metal box a distance of 15.0 m across the floor. The rope is held at an angle of 46.0° with the floor, and a force of 628 N is applied to the rope. How much work does the rope do on the box?

Solution: $W = Fd\ cos\ \theta$ $W = (628)(15.0)(\cos 46.0)$=6543.7 J ≈6.54 ×10^3 J

Relate the gravitational potential energy to the mass of the object and its height above or below a reference level (GPE=mgh)

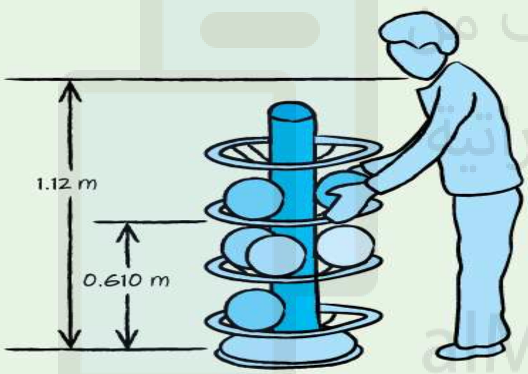
GRAVITATIONAL POTENTIAL ENERGY

You lift a 7.30-kg bowling ball from the storage rack and hold it up to your shoulder. The storage rack is 0.610 m above the floor and your shoulder is 1.12 m above the floor.

a. When the bowling ball is at your shoulder, what is the ball-Earth system's gravitational potential energy relative to the floor?

b. When the bowling ball is at your shoulder, what is the ball-Earth system's gravitational potential energy relative to the rack?

c. How much work was done by gravity as you lifted the ball from the rack to shoulder level?



2. SOLVE FOR THE UNKNOWN

a. Set the reference level to be at the floor.

Determine the gravitational potential energy of the system when the ball is at shoulder level.

$$GPE_{s\ rel\ f} = mgh_s = (7.30\ kg)(9.8\ N/kg)(1.12\ m)$$ Substitute $m = 7.30$ kg, $g = 9.8$ N/kg, $h_s = 1.12$ m

$$= 8.0 \times 10^1\ J$$

b. Set the reference level to be at the rack height.

Determine the height of your shoulder relative to the rack.

$h = h_s - h_r$

Determine the gravitational potential energy of the system when the ball is at shoulder level.

$$GPE_{s\ rel\ r} = mgh = mg\ (h_s - h_r)$$ Substitute $h = h_s - h_r$

$$= (7.30\ kg)(9.8\ N/kg)(1.12\ m - 0.610\ m)$$ Substitute $m = 7.30$ kg, $g = 9.8$ N/kg, $h_s = 1.12$ m, $h_r =$ 0.610 m

$$= 36\ J$$ This also is equal to the work done by you as you lifted the ball.

c. The work done by gravity is the weight of the ball times the distance the ball was lifted.

$$W = Fd = -(mg)\,h = -(mg)\,(h_s - h_r)$$ The weight opposes the motion of lifting, so the work is negative.

$$= -(7.30\text{ kg})\,(9.8\text{ N/kg})\,(1.12\text{ m} - 0.610\text{ m})$$ Substitute $m = 7.30$ kg, $g = 9.8$ N/kg, $h_s = 1.12$ m, $h_r = 0.610$ m

$$= -36\text{ J}$$

3. EVALUATE THE ANSWER

- **Are the units correct?** Both potential energy and work are measured in joules.
- **Does the answer make sense?** The system should have a greater *GPE* measured relative to the floor than relative to the rack because the ball's distance above the floor level is greater than the ball's distance above the rack.

32. A boy lifts a 2.2-kg book from his desk, which is 0.80 m high, to a bookshelf that is 2.10 m high. What is the potential energy of the book-Earth system relative to the desk when the book is on the shelf?

$$GPE = mg(h_f - h_i)$$

$$= (2.2\text{ kg})(9.8\text{ N/kg})(2.10\text{ m} - 0.80\text{ m})$$

$$= 28\text{ J}$$

LO – 9: Apply the law of conservation of mechanical energy to solve problems.

Figure 24: The conservation of mechanical energy is an important consideration in designing roller coaster, ski slopes, and the pendulum for the grandfather clocks

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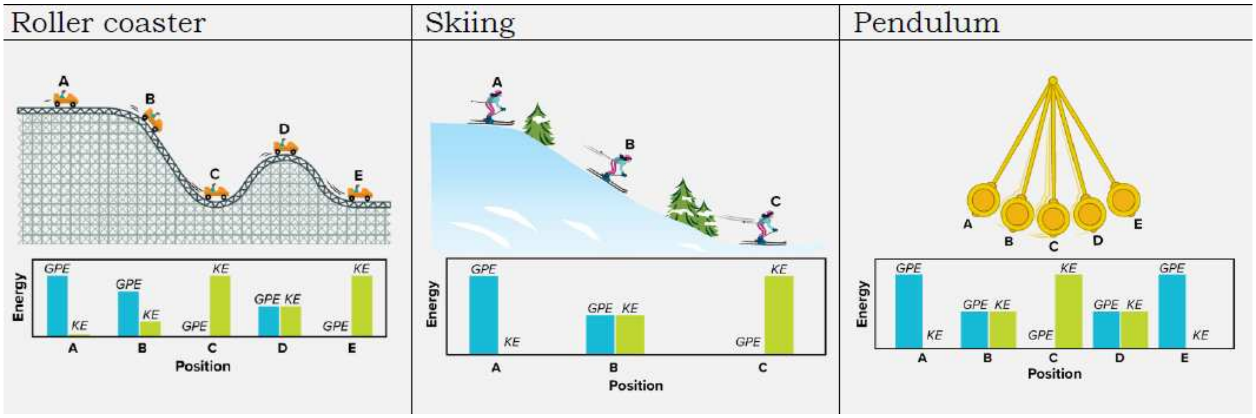

KE + GPE = CONSTANT.

LO – 10: Relate the gravitational potential energy to the mass of the object and its height above or below a reference level. ($GPE=m\,g\,h$)

Q32: A boy lifts a 2.2-kg book from his desk, which is 0.80 m high, to a bookshelf that is 2.10 m high. What is the potential energy of the book-Earth system relative to the desk when the book is on the shelf?

$GPE=m\,g\,h$

$GPE=(2.2)(9.8)(2.10-0.80)=28.028\,J \approx 28\,J$

9 Define the term elastic potential energy and give examples as mentioned in the textbook

Elastic Potential Energy

When the bow string shown in **Figure 17** is pulled, work is done on the bow string and energy is transferred to the bow. If you identify the system as the bow, the arrow, and Earth, the energy of the system increases. When the string and the arrow are released, the stored energy is changed into kinetic energy.

Figure 17 The archer-bow-arrow system has maximum elastic potential energy before the string is released, as shown on the left. When the arrow and string disengage, the elastic potential energy is completely transformed into kinetic energy, as shown on the right.

The stored energy due to the pulled string and bent bow is **elastic potential energy,** which is stored energy due to an object's change in shape. Systems that include springs, rubber bands, and trampolines have elastic potential energy.

You can also store elastic potential energy in a system when you bend an elastic object in that system. For example, when stiff metal or bamboo poles were used in pole-vaulting, the poles did not bend easily. Little work was done on the poles, and the poles did not store much potential energy. Since flexible fiberglass poles were introduced, however, record pole-vaulting heights have soared.

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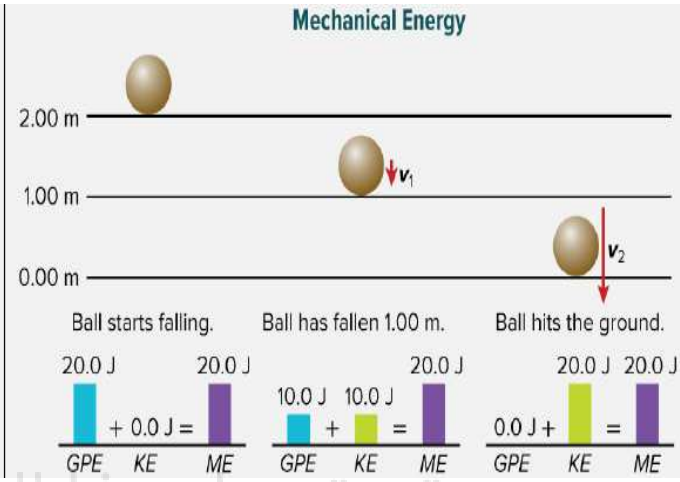
A pole-vaulter runs with a flexible pole and plants its end into a socket in the ground. When the pole-vaulter bends the pole, as shown in **Figure 18,** some of the pole-vaulter's kinetic energy is transformed to elastic potential energy. When the pole straightens, the elastic potential energy is transformed to gravitational potential energy and kinetic energy as the pole-vaulter is lifted as high as 6 m above the ground.

LO – 11: Define mechanical energy as the sum of all kinetic and potential energies of the system.

Figure 22: when a bowling ball is dropped, mechanical energy is conserved.

$m_{ball} = 1.02\ kg$



Mechanical energy

You often focus on the energy that comes from the motions of and interactions between objects. The sum of the *KE* and *PE* of the objects in a system is the system's **mechanical energy** (*ME*). The *KE* includes both the translational and rotational kinetic energies of the objects in the system. Potential energy includes the gravitational and elastic potential energies of the system. In any system, mechanical energy is represented as follows.

Mechanical Energy of a System

The mechanical energy of a system is equal to the sum of the *KE* and *PE* of the system's objects.

$$ME = KE + PE$$

Apply the law of conservation of mechanical energy to solve problems

KEi + PEi = KEf + PEf

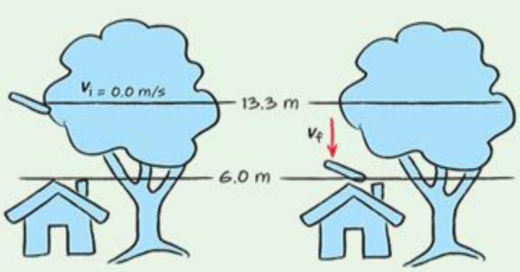
EXAMPLE Problem 5

CONSERVATION OF MECHANICAL ENERGY

A 22.0-kg tree limb is 13.3 m above the ground. During a tropical storm, it falls on a roof that is 6.0 m above the ground.

a. Find the kinetic energy of the limb when it reaches the roof. Assume that the air does no work on the tree limb.

b. What is the limb's speed when it reaches the roof?



41.A skier starts from rest at the top of a hill that is 45.0 m high, skis down a 30° incline into a valley, and continues up a hill that is 40.0 m high. The heights of both hills are measured from the valley floor. Assume that friction is negligible and ignore the effect of the ski poles

a. How fast is the skier moving at the bottom of the valley?

Mechanical energy is conserved,

so $KE_i + PE_i + KE_f + PE_f$

$$0 + mgh = \frac{1}{2}mv^2 + 0$$

$$v^2 = 2gh$$

$$v = \sqrt{2gh}$$

$$= \sqrt{(2)(9.8\ \text{N/kg})(45.0\ \text{m})}$$

$$= 3.0 \times 10^1\ \text{m/s}$$

b. What is the skier's speed at the top of the second hill?

$$KE_i + PE_i = KE_f + PE_f$$

$$0 + mgh_i = \frac{1}{2}mv^2 + mgh_f$$

$$v^2 = 2g(h_i - h_f)$$

$$= \sqrt{2g(h_i - h_f)}$$

$$= \sqrt{(2)(9.8\ \text{N/kg})(45.0\ \text{m} - 40.0\ \text{m})}$$

$$= 9.9\ \text{m/s}$$

c. Do the angles of the hills affect your answers?

No, the angles do not have any impact.

Q.12 Explain Kepler's First Law which states that the planets follow elliptical paths with the sun at one focus.

Q.13 Explain Kepler's Second Law which states that an imaginary line from the Sun to a planet sweeps out equal areas in equal time intervals

Q.14 Explain Kepler's Third Law which states that the square of the ratio of the periods of any two planets revolving about the Sun is equal to the cube of the ratio of their average distances from the Sun and write it in equation form ((T A/TB)2=(rA /rB)3

LO – 12: Define gravitational force as the force of attraction between two objects of given mass.

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Law of Universal Gravitation:

The gravitational force is equal to the universal gravitational constant, times the mass of object 1, times the mass of object 2, divided by the distance between the centers of the objects, squared.

$$F_g = \frac{G\, m_1 m_2}{r^2}$$

Gravitation between objects depends on the product of the masses of the objects.

The gravitational force between objects is inversely proportional to the square of the distance between the objects.

LO – 15: Calculate the orbital period of a satellite.

Q 21, P 181: Two satellites are in circular orbits about Earth. One is 150 km above the surface, the other is 160 km.

a. Which satellite has the larger orbital period?

b. Which has the greater speed?

$M_{Earth} = 5.97 \times 10^{24} kg$ $R_{Earth} = 6.371 \times 10^{6} m$

Note that: $(r = h + R_{Earth})$

Solution: (The periodic time)

	Periodic time (T)
1st satellite $(h = 150000\ m)$ $r_1 = (150 \times 10^3) + (6.371 \times 10^6)$ $r_1 = 6.521 \times 10^6\ m$	$T_1 = 2\pi\sqrt{\frac{r_1^3}{G\ m_E}}$ $T_1 = 2\pi\sqrt{\frac{(6.521 \times 10^6)^3}{(6.67 \times 10^{-11})(5.97 \times 10^{24})}}$ $T_1 = 5243\ s = 87.4\ minutes$
2nd satellite $(h = 160000\ m)$ $r_2 = (160 \times 10^3) + (6.371 \times 10^6)$ $r_2 = 6.531 \times 10^6\ m$	$T_2 = 2\pi\sqrt{\frac{(6.531 \times 10^6)^3}{(6.67 \times 10^{-11})(5.97 \times 10^{24})}}$ $T_2 = 5255\ s = 87.6\ minutes$

OR, simply, the second satellite would have a greater periodic time as its height (160 km) is greater than the first satellite (150 km). $(T2 > T1)$

Solution: (The speed)

	Periodic time (T)
1st satellite $(h = 150000\ m)$ $r = (150 \times 10^3) + (6.371 \times 10^6)$ $r = 6.521 \times 10^6\ m$	$v_1 = \sqrt{\frac{G\ m_E}{r_1}}$ $v_1 = \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{(6.521 \times 10^6)}}$ $v_1 = 7814.4\ m/s = 7.8144\ km/s$
2nd satellite $(h = 160000\ m)$ $r = (160 \times 10^3) + (6.371 \times 10^6)$ $r = 6.531 \times 10^6\ m$	$v_2 = \sqrt{\frac{G\ m_E}{r_2}}$ $v_2 = \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{(6.531 \times 10^6)}}$ $v_2 = 7808.4\ m/s = 7.8084\ km/s$

OR, simply, the first satellite would have a greater speed as its height (150 km) is less than the second satellite (160 km). $(v1 > v2)$

LO – 16: Recall pressure as the perpendicular component of a force divided by the area of the surface to which it is applied (P = F/A)

.

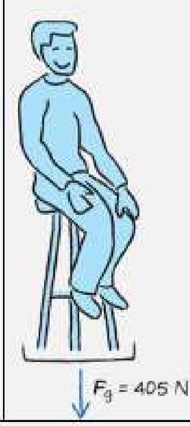
Example 1, P 234: A child weights 364 N and sits on a three – legged stool, which weights 41 N. The bottoms of the stool's legs touch the ground over a total area of 19.3 $cm3$

.

a. What is the average pressure that the child and the stool exert on the ground?

b. How does the pressure change when the child leans over so that only two legs of the stool touch the floor?

Solution:

((a) $P = \frac{F}{A}$ $P = \frac{(364+41)}{19.3 \times 10^{-4}}$ $P = 209844\ Pa$ $P = 2.10 \times 10^{2}\ kPa$	((b) $P = \frac{F}{A}$ $P = \frac{(364+41)}{\left(\frac{19.3}{3}\right) \times 2 \times 10^{-4}}$ $P = 314766\ Pa$ $P = 3.14 \times 10^{2}\ kPa$	

PART THREE – Written part

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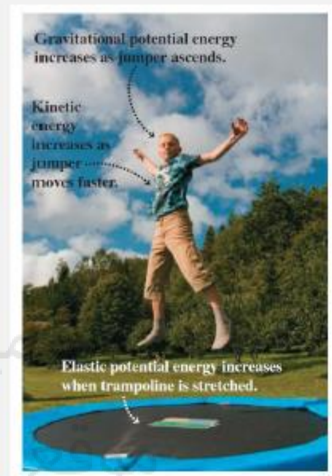
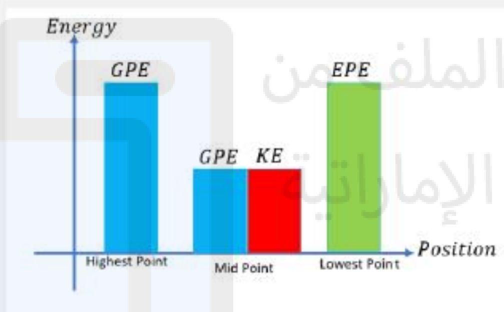
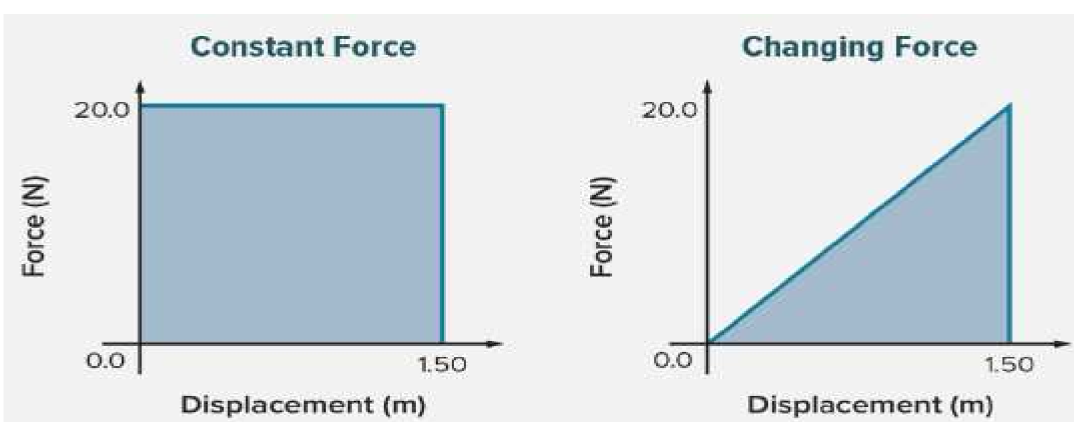
LO – 17: Apply the law of conservation of energy to examples like roller coaster rides, ski slopes, inclined planes/ hills, and pendulums

Q 47, P 217: A child jumps on a trampoline. Draw energy bar diagrams to show the forms of energy in the following situations.
a. The child is at the highest point.
b. The child is at the lowest point.

At highest point	At lowest point	
All of the system's energy is gravitational potential energy. $ME = GPE$	All of the system's energy is elastic potential energy. $ME = EPE$	
		

LO – 18: Determine graphically the work done by a force from the area of force versus
displacement graph

Figure 4, P 191: The area under a force – displacement graph is equal to the work.



LO – 19: Apply the relationship between power, the work done by a force, and the time interval in which that work is done (P=W/t)

Example 3, P 197: An electric motor lifts an elevator 9.00 m in 15.0 s by exerting a force of $1.20 \times 10^4 N$. What power does the motor produce in kW?

Solution:

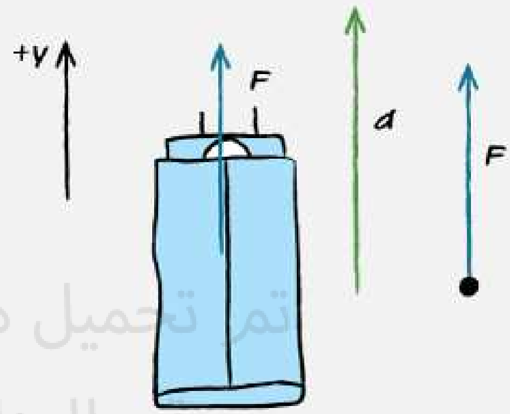
$$P = \frac{W}{t}$$

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

$$P = \frac{(1.20 \times 10^4)(9.00)}{(15.0)}$$

$$P = 7200\ W$$

$$P = 7.20\ kW$$



LO – 20: Apply the law of universal gravitation to calculate the gravitational force or other unknown parameters.

Question 9, P 172: Predict the gravitational force between two 15-kg balls whose centers are 35 cm apart. What fraction is this of the weight of one ball?

Solution:

$$F = \frac{Gm_1m_2}{r^2}$$

$$F = \frac{(6.67 \times 10^{-11})(15)(15)}{(0.35)^2} = 1.22 \times 10^{-7} N$$

Comparison:

$$\frac{F}{Weight} = \frac{1.22 \times 10^{-7}}{15 \times 9.8} = 2.50 \times 10^{-9}$$

Means that the weight of one the balls is about 2000 million times greater than the gravitational force between the two balls.