Mr. Wright's Math Extravaganza

Physical Science

(Chemistry, Physics, Physical Science)

Energy Conversion

Unit 06 Energy

Level 2.0: 70% on test, Level 3.0: 80% on test, Level 4.0: level 3.0 and success on energy conversion lab

Score	I Can Statements
4.0	☐ I can invent a device that converts one form of energy into another.
3.5	In addition to score 3.0 performance, partial success at score 4.0 content.
3.0	☐ I can explain how to convert energy from one form to another.
2.5	No major errors or omissions regarding score 2.0 content, and partial success at score 3.0 content.
2.0	☐ I can explain that an object's energy is a combination of kinetic and potential energy. ☐ I can describe how various forms of energy relate to kinetic energy, potential energy, or both. ☐ I can use the law of conservation of energy to explain why energy is always transferred from place to place or from form to form. ☐ I can use the equations to calculate potential, translational kinetic, and rotational kinetic energy. ☐ I can describe how work done on a system changes the energy of the system. ☐ I can describe how power is represented by the rate at which energy in a system is changed.
1.5	Partial success at score 2.0 content, and major errors or omissions regarding score 3.0 content.
1.0	With help, partial success at score 2.0 content and score 3.0 content.
0.5	With help, partial success at score 2.0 content but not at score 3.0 content.
0.0	Even with help, no success.

Physics 06-01 Work and Power **_Name: _______________________**

Work

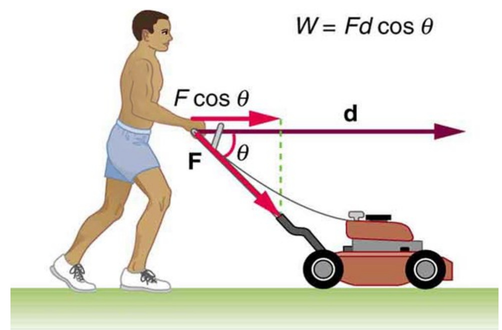
Depends on ____________ and the ____________ the force moves the object

Want the force in the direction of the ____________

$$W = Fd\cos\theta$$

Unit: N m = Joule (J)

____________ (but can be positive and negative)



Marcy pulls a backpack on wheels down the 100-m hall. The 60-N force is applied at an angle of 30° above the horizontal. How much work is done by Marcy?

Mark is carrying books (200 N) down the 100-m hall. How much work is Mark doing on the books?

You carry some books (200 N) while walking down stairs height 2 m and length 3 m. How much work do you do?

A suitcase is hanging straight down from your hand as you ride an escalator. Your hand exerts a force on the suitcase, and this force does work. Which one of the following is correct?

a. The W is negative when you ride up and positive when you ride down
b. The W is positive when you ride up and negative when you ride down
c. The W is positive
d. The W is negative

Power

Rate that ______________ is ______________: $P = \frac{W}{t}$

Unit: joule/s = watt (W)

Power is the ______________ that ______________ is ______________

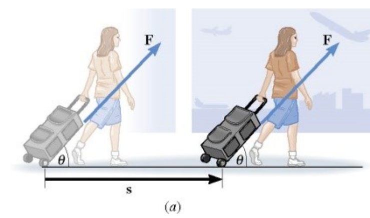
A 1000 kg car accelerates from 0 to 100 km/h in 3.2 s on a level road. Find the average power of the car.

Electrical Energy is often measured in ______________ because $Pt = W$

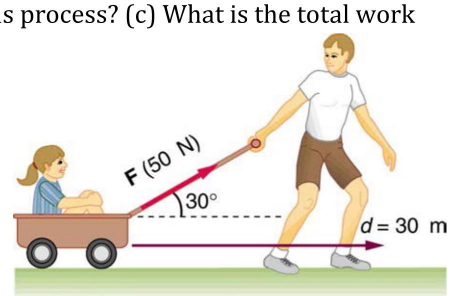
If it costs $0.10 per kWh, how much will it cost to run a 1000 W microwave for 2 minutes?

Physics 06-01 Work and Power	*Name: ____________________*
Practice Work	

1. A box is being moved with a velocity *v* by a force *P* (parallel to *v*) along a level horizontal floor. The normal force is F_N, the kinetic frictional force is f_k, and the weight of the box is *mg*. Decide which forces do positive, zero, or negative work. Provide a reason for each of your answers.
2. A sailboat is moving at a constant velocity. (a) Is work being done by a net external force acting on the boat? Explain. (b) Recognizing that the wind propels the boat forward and the water resists the boat's motion, what does your answer in part (a) imply about the work done by the wind's force compared to the work done by the water's resistive force?
3. Work done on a system puts energy into it. Work done by a system removes energy from it. Give an example for each statement.
4. The brakes of a truck cause it to slow down by applying a retarding force of 3.0×10^3 N to the truck over a distance of 850 m. What is the work done by this force on the truck? Is the work positive or negative? Why? (Cutnell 6.1) $\mathbf{-2.6 \times 10^6}$ **J**
5. A person pulls a toboggan for a distance of 35.0 m along the snow with a rope directed 25.0° above the snow. The tension in the rope is 94.0 N. (a) How much is done on the toboggan by the tension force? (b) How much work is done if the same tension is directed parallel to the snow? (Cutnell 6.3) **2980 J, 3290 J**
6. A 75.0-kg man is riding an escalator in a shopping mall. The escalator moves the man at a constant velocity from ground level to the floor above, a vertical height of 4.60 m. What is the work done on the man by (a) the gravitational force and (b) the escalator? (Cutnell 6.4) **-3380 J, 3380 J**



7. Suppose in the picture that 1100 J of work are done by the force *F* = 30.0 N in moving the suitcase a distance of 50.0 m. At what angle θ is the force oriented with respect to the ground? (Cutnell 6.5) **42.8°**
8. A person pushes a 16.0-kg shopping cart at a constant velocity for a distance of 22.0 m. She pushes in a direction 29.0° below the horizontal. A 48.0-N frictional force opposes the motion of the cart. (a) What is the magnitude of the force that the shopper exerts? (review) Determine the work done by (b) the pushing force, (c) the frictional force, and (d) the gravitational force. (Cutnell 6.7) **54.9 N, 1060 J, -1060 J, 0 J**
9. (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? (OpenStax 7.3) $\mathbf{5.92 \times 10^5}$ **J,** $\mathbf{-5.88 \times 10^5}$ **J, 0 J**
10. How much work is done by the boy pulling his sister 30.0 m in a wagon as shown in Figure 7.36? Assume no friction acts on the wagon. (OpenStax 7.6) $\mathbf{1.30 \times 10^3}$ **J**



11. Is it correct to conclude that one engine is doing twice the work of another just because it is generating twice the power? Explain.
12. Explain, in terms of the definition of power, why energy consumption is sometimes listed in kilowatt-hours rather than joules.
13. A spark of static electricity, such as that you might receive from a doorknob on a cold dry day, may carry a few hundred watts of power. Explain why you are not injured by such a spark.
14. A person is making homemade ice cream. She exerts a force of magnitude 22 N on the free end of the crank handle, and this end moves in a circular path of radius 0.28 m. The force is always applied parallel to the motion of the handle. If the handle is turned once every 1.3 s, what is the average power being expended? (Cutnell 6.56) **30 W**
15. What is the cost of operating a 3.00-W electric clock for a year if the cost of electricity is $0.0900 per kWh? (OpenStax 7.33) **$2.37**
16. A large household air conditioner may consume 15.0 kW of power. What is the cost of operating this air conditioner 3.00 h per day for 30.0 d if the cost of electricity is $0.110 per kWh? (OpenStax 7.34) **$149**
17. A 500-kg dragster accelerates from rest to a final speed of 110 m/s in 400 m (about a quarter of a mile) and encounters an average frictional force of 1200 N. What is its average power output in watts and horsepower if this takes 7.30 s (1 hp = 746 W)? (OpenStax 7.37) $\mathbf{4.80 \times 10^5}$ **W, 643 hp**

Physics 06-02 Types of Energy **Name: ________________**

Energy is the ____________ to do ____________

Kinetic Energy

Energy due to ____________

$$KE = \frac{1}{2}mv^2$$

____

Unit: Joule

Rotational Kinetic Energy

$$KE = \frac{1}{2}I\omega^2$$

Refer back to previous notes to find the formulas for the moment of inertia, *I*.

Potential Energy

Energy due to ____________

Gravitational potential energy

$$PE_g = mgh$$

Since the force of gravity is ____________ and the displacement and force must be in same ____________, we only worry about the ____________ distance

The ____________ the object takes doesn't matter, just the ____________ ____________

Potential Energy is not ____________; it is a ____________

h is measured from ________________________ point. Just be ____________.

Spring potential energy

$$PE_s = \frac{1}{2}kx^2$$

A 5.2-kg Canada goose is flying towards you at 18 m/s and a height of 3 m. What is its (a) kinetic energy and (b) potential energy?

Let's say a coil suspension spring on a car is compressed 9.0 cm after it is installed in a car. If it has a spring constant of 33000 N/m, what is the potential energy stored in the spring?

Physics 06-02 Types of Energy **Name: ________________**

Practice Work

1. What is the difference between kinetic and potential energy?
2. If there is 235 J of energy, how much work can be done? Why? (RW) **235 J**
3. Compare the kinetic energy of a 20,000-kg truck moving at 110 km/h with that of an 80.0-kg astronaut in orbit moving at 27,500 km/h. (OpenStax 7.9) $\mathbf{9.34 \times 10^6}$ **J,** $\mathbf{2.33 \times 10^9}$ **J**
4. (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. (OpenStax 7.10) **1.47 m/s**
5. (a) What is the translational (nonrotational) kinetic energy of a 0.50-kg can of soup (d = 5.0 cm, h = 6.0 cm) with a speed of 2.5 m/s? (b) What is its rotational kinetic energy if it is also rolling across the floor assuming it is a solid cylinder like a condensed soup? (hint: find ω first) (c) How much work is required to stop the can? (RW) **1.56 J; 0.781 J; 2.34 J**
6. (a) What is the translational (nonrotational) kinetic energy of a 165-g billiard ball (d = 57 mm) with a speed of 4.1 m/s? (b) What is its rotational kinetic energy if it is also rolling across the table assuming it is a solid sphere? (hint: find ω first) (c) How much work is required to stop the ball? (RW) **1.39 J; 0.555 J; 1.94 J**
7. Two cars, A and B, are traveling with the same speed of 40.0 m/s, each having started from rest. Car A has a mass of 1200 kg, and car B has a mass of 2000 kg. Compared to the work required to bring car A up to speed, how much additional work is required to bring car B up to speed? (Cutnell 6.17) $\mathbf{6.4 \times 10^5}$ **J**
8. Relative to the ground, what is the gravitational potential energy of a 55.0-kg person who is at the top of the Sears Tower, a height of 443 m above the ground? (Cutnell 6.27) $\mathbf{2.39 \times 10^5}$ **J**
9. A hydroelectric power facility converts the gravitational potential energy of water behind a dam to electric energy. What is the gravitational potential energy relative to the generators of a lake of volume 50.0 km^3 (mass = 5.00×10^{13} kg), given that the lake has an average height of 40.0 m above the generators? (OpenStax 7.16) $\mathbf{1.96 \times 10^{16}}$ **J**
10. A 75.0-kg skier rides a 2830-m-long lift to the top of a mountain. The lift makes an angle of 14.6° with the horizontal. What is the change in the skier's gravitational potential energy? (Cutnell 6.29) $\mathbf{5.24 \times 10^5}$ **J**
11. The spring in a certain Nerf™ toy dart gun has a spring with a spring constant of 318 N/m. How much energy is stored when it is compressed 77 mm when loading a dart? (RW) **0.943 J**
12. What would be the constant of a spring that stores 5.00×10^2 J of energy when compressed 50 cm? (RW) $\mathbf{4.00\times10^3}$ **N/m**

Physics 06-03 Mechanical Energy Conservation Name: ________________

Energy can be ____________ from one ____________ to ____________.

Law of Conservation of Mechanical Energy

$$PE_f + KE_f = PE_0 + KE_0$$

if only ____________________ and ____________________ energy

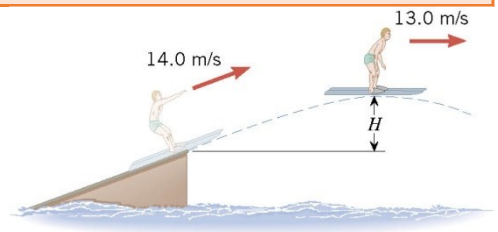
A toy gun uses a spring to shoot plastic balls (m = 50 g). The spring is compressed by 3.0 cm. Let k=2.22×10^5 N/m. (a) Of course, you have to do some work on the gun to arm it. How much work do you have to do? (b) Suppose you fire the gun horizontally. How fast does the ball leave the gun? (c) Now suppose you fire the gun straight upwards. How high does the ball go?

A 1500-kg car is driven off a 50-m cliff during a movie stunt. If it was going 20 m/s as it went off the cliff, how fast is it going as it hits the ground?

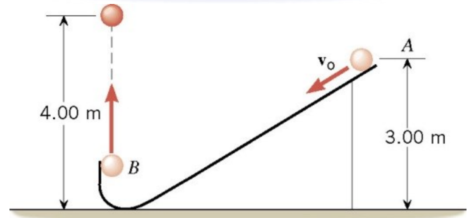
Practice Work

1. Suppose the total mechanical energy of an object is conserved. (a) If the kinetic energy decreases, what must be true about the gravitational potential energy? (b) If the potential energy decreases, what must be true about the kinetic energy? (c) If the kinetic energy does not change, what must be true about the potential energy?
2. A person is riding a Ferris wheel. When the wheel makes one complete turn, is the net work done by the gravitational force positive, negative, or zero? Justify your answer.
3. Ancient Israel used a sling as a weapon. If the 250-g stone were accidentally launched straight up at 25 m/s, how high would it go? (RW) **31.9 m**
4. David used a sling against Goliath. If the 250-g stone were launched at 25 m/s at an angle of 60° above the horizontal, how high would it go? (Hint: At the highest point, the speed is not zero.) (RW)
5. "Rocket man" has a propulsion unit strapped to his back. He starts from rest on the ground, fires the unit, and is propelled straight upward. At a height of 16 m, his speed is 5.0 m/s. His mass, including the propulsion unit, is about 136 kg. Find the work done by the force generated by the propulsion unit. (Cutnell 6.31) $\mathbf{2.3 \times 10^4}$ **J**
6. 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? (OpenStax 7.18) **1.8 J, 8.6 J**

7. A water-skier lets go of the tow rope upon leaving the end of a jump ramp at a speed of 14.0 m/s. As the drawing indicates, the skier has a speed of 13.0 m/s at the highest point of the jump. Ignoring air resistance, determine the skier's height H above the top of the ramp at the highest point. (Cutnell 6.34) **1.4 m**



8. A particle, starting from point A in the drawing, is shot down the curved runway. Upon leaving the runway at point B, the particle is traveling straight upward and reaches a height of 4.00 m above the floor before falling back down. Ignoring friction and air resistance, find the speed of the particle at point A. (Cutnell 6.38) **4.43 m/s**

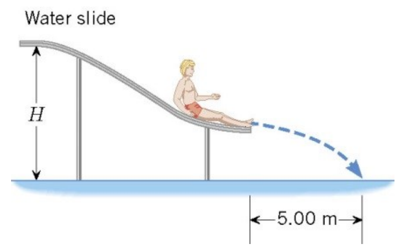


9. A 100-g toy car is propelled by a compressed spring that starts it moving. The car follows the curved track. Show that the final speed of the toy car is 0.687 m/s if its initial speed is 2.00 m/s and it coasts up the frictionless slope, gaining 0.180 m in altitude. (OpenStax 7.20) **0.687 m/s**

10. A 5.00×10^5-kg subway train is brought to a stop from a speed of 0.500 m/s in 0.400 m by a large spring bumper at the end of its track. What is the force constant k of the spring? (OpenStax 7.22) $\mathbf{7.81 \times 10^5}$ **N/m**

11. A pogo stick has a spring with a force constant of 2.50×10^4 N/m, which can be compressed 12.0 cm. To what maximum height can a child jump on the stick using only the energy in the spring, if the child and stick have a total mass of 40.0 kg? (OpenStax 7.23) **0.459 m**

12. A water slide is constructed so that swimmers, starting from rest at the top of the slide, leave the end of the slide traveling horizontally. As the drawing shows, one person hits the water 5.00 m from the end of the slide in a time of 0.500 s after leaving the slide. Ignoring friction and air resistance, find the height H in the drawing. (Hint: Start by using projectile motion to find the speed when the person hits the water, then use conservation of mechanical energy to find the height.) (Cutnell 6.41) **6.33 m**



Physics 06-04 Work and Conservation of Energy **Name: ___________________**

Work done by external force

$$E_0 + W_{net} = E_f$$

Law of Conservation of Energy

The total energy is ______________ in any process. It may __________ form or be ______________ from one system to another, but the total __________ the __________.

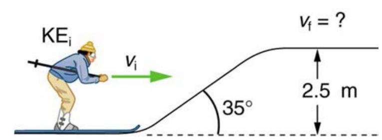
A rocket starts on the ground at rest. Its final speed is 500 m/s and height is 5000 m. If the mass of the rocket stays approximately 200 kg, find the work done by the rocket engine.

A 1500-kg car's brakes failed and it coasts down a hill from rest. The hill is 10 m high and the car has a speed of 12 m/s at the bottom of the hill. How much work did friction do on the car?

Captain Proton's rocket pack provides 800,000 J of work to propel him from resting on his ship which is near the earth to 50 m above it. Captain Proton's mass is 90 kg. What is his final velocity?

Physics 06-04 Work and Conservation of Energy	***Name: ___________________***
Practice Work	

1. List four different forms or types of energy. Give one example of a conversion from each of these forms to another form.
2. A basketball player makes a jump shot. The 0.600-kg ball is released at a height of 2.00 m above the floor with a speed of 7.20 m/s. The ball goes through the net 3.10 m above the floor at a speed of 4.20 m/s. What is the work done on the ball by air resistance, an external force? (Cutnell 6.46) **−3.8 J**
3. A projectile of mass 0.750 kg is shot straight up with an initial speed of 18.0 m/s. (a) How high would it go if there were no air friction? (b) If the projectile rises to a maximum height of only 11.8 m, determine the magnitude of the average force due to air resistance. (Cutnell 6.48) **16.5 m, 2.9 N**
4. The external force pulling a 1500-kg car up a mountain road does 4.70×10^6 J of work on the car. The car starts from rest at sea level and has a speed of 27.0 m/s at an altitude of 200 m above sea level. Obtain the work done on the car by the combined forces of friction and air resistance, both of which are nonconservative forces. (Cutnell 6.49) $\mathbf{-1.21 \times 10^6}$ **J**
5. A 60.0-kg skier with an initial speed of 12.0 m/s coasts up a 2.50-m high rise as shown in the figure. Find her final speed at the top, given that the coefficient of friction between her skis and the snow is 0.0800. (Hint: Find the distance traveled up the incline assuming a straight-line path as shown in the figure.) (OpenStax 7.24) **9.46 m/s**



6. (a) How high a hill can a car coast up (engine disengaged) if work done by friction is negligible and its initial speed is 110 km/h? (b) If, in actuality, a 750-kg car with an initial speed of 110 km/h is observed to coast up a hill to a height 22.0 m above its starting point, how much thermal energy was generated by friction? (c) What is the average force of friction if the hill has a slope 2.5° above the horizontal? (OpenStax 7.25) **47.6 m,** $\mathbf{1.88 \times 10^5}$ **J, 374 N**
7. Using energy considerations and assuming negligible air resistance, show that a rock thrown from a bridge 20.0 m above water with an initial speed of 15.0 m/s strikes the water with a speed of 24.8 m/s independent of the direction thrown. (OpenStax 7.27) **24.8 m/s**
8. If the energy in fusion bombs were used to supply the energy needs of the world, how many of the 9-megaton variety would be needed for a year's supply of energy (using data from Table 7.1)? This is not as farfetched as it may sound—there are thousands of nuclear bombs, and their energy can be trapped in underground explosions and converted to electricity, as natural geothermal energy is. (Annual world energy use = 4×10^{20} J; Large fusion bomb (9 megaton) = 3.8×10^{16} J) (OpenStax 7.28) $\mathbf{1 \times 10^4}$ **bombs**
9. Use of hydrogen fusion to supply energy is a dream that may be realized in the next century. Fusion would be a relatively clean and almost limitless supply of energy. To illustrate this, calculate how many years the present energy needs of the world could be supplied by one millionth of the oceans' hydrogen fusion energy. (Fusion of all the hydrogen in Earth's oceans = 10^{34} J; Annual world energy use = 4×10^{20} J) (OpenStax 7.29) $\mathbf{2.5 \times 10^7}$ **years**

Physics 06-05 Simple Machines	*Name:* ________________
Simple Machines	

Make ____________ easier

Does not change the amount of ____________ done, does change the ____________ required.

Less force means moves over more ____________

Ideal Mechanical Advantage

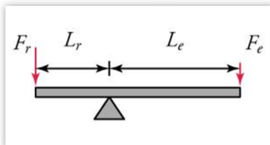
The ratio of how much the simple machine multiplies the ____________ force (F_e) into the ____________ force (F_r) required force to do work

$$IMA = \frac{F_r}{F_e} = \frac{d_e}{d_r}$$

Lever

The rotation point is called the ____________

$$IMA = \frac{L_e}{L_r}$$



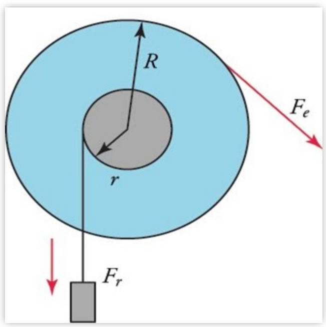
Wheel and Axle

____________ where effort arm can ____________ completely around the fulcrum

d_e is the radius of the ____________ R

d_r is the radius of the ____________ r

$$IMA = \frac{R}{r}$$



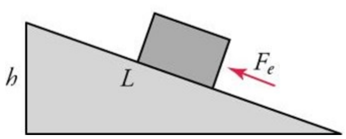
Inclined Plane

____________ surface

d_e = ____________

d_r = ____________

$$IMA = \frac{L}{h}$$



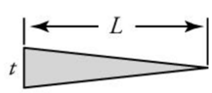
Wedge

Two ____________ ____________ put together

d_e = ____________

d_r = ____________

$$IMA = \frac{L}{t}$$



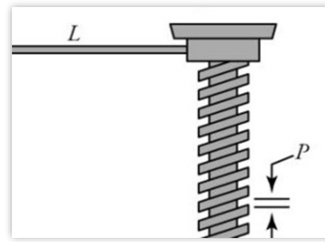
Screw

____________ ____________ wrapped around a ____________ ____________

d_e = radius of ____________

$(2\pi L)d_r$ = distance between ____________ (pitch, p)

$$IMA = \frac{2\pi L}{P}$$



Pulley

Rope wrapped around a ____________ ____________

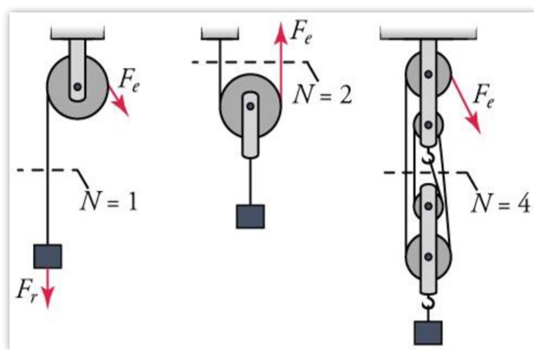
d_e = distance the ____________ is pulled

d_r = distance the ____________ is lifted

When a 2nd rope supports the weight, then the distance it travels is ____________

IMA = number of ____________ supporting the weight

$$IMA = N$$



Find the ideal mechanical advantage of a ramp of length 10 m and height 3 m.

Find the ideal mechanical advantage of a 3 m lever whose fulcrum is 50 cm from one end with the load.

What is the ideal mechanical advantage of a pulley that is supporting the load by 4 ropes?

How much rope needs to be pulled to lift the load 2 m?

If the load's mass is 120 kg, how much force is required to lift the load?

Efficiency

Useful energy output is always __________ than energy or work __________

$$Efficiency\ (Eff) = \frac{\text{useful energy or work output}}{\text{total energy or work input}} \times 100\% = \frac{W_{out}}{W_{in}} \times 100\%$$

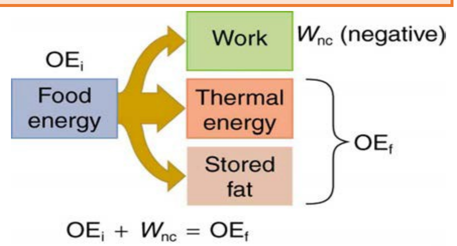
The actual efficiency of a screw is 94%. The screwdriver handle has a radius of 1.25 cm, and the screw has a pitch of 1 mm and radius of 1.2 mm. If it takes 9 N of force on the screwdriver to screw it in, what is the frictional force resisting the screw?

Practice Work

1. How does a simple machine make work easier?
2. Which type of simple machine is a knife?
3. Why are machines not 100% efficient?
4. What is the IMA of a wedge that is 12 cm long and 3 cm thick? (OpenStaxHS 9.31) **4**
5. What is the IMA of a 3-m lever where the fulcrum is at one end and the load is 40 cm from the fulcrum (like a wheelbarrow)? (RW) **7.5**
6. A pulley system requires a person to pull down 20 m of rope to lift a 500 kg go kart 4 m. (a) What is the mechanical advantage of the pulley system? (b) How many ropes support the load? (c) What effort force is required to lift the go kart? (RW) **5; 5; 980 N**
7. The axle for a 2003 Kia Rio is 73.5 mm in diameter. The tire's diameter is 583 mm. (a) What is the mechanical advantage of this wheel and axle? (b) If the input force is 3840 N, what is the ideal resistive force? (c) If the resistive force is actually 21400 N, what is the size of the friction force? (RW) **7.93; 30500 N; 9100 N**
8. A man is using a wedge to split a block of wood by hitting the wedge with a hammer. This drives the wedge into the wood creating a crack in the wood. When he hits the wedge with a force of 400 N it travels 4 cm into the wood. This caused the wedge to exert a force of 1,400 N sideways increasing the width of the crack by 1 cm. What is the efficiency of the wedge? (OpenStaxHS 9.19) **87.5%**
9. An access ramp to a building needs to rise 1.5 m from the ground to the door. (a) If the mechanical advantage is 3, what length of ramp is needed? (b) A 70-kg person is pushed up the ramp in a wheelchair. What is the ideal force required to push it up? (c) If the efficiency is 98% due to friction, what is the actual force required to push the person up the ramp? (RW) **4.5 m; 229 N; 233 N**
10. A screwdriver handle has a diameter of 2.25 cm. The screw has an ideal mechanical advantage of 40. (a) What is the pitch of the screw? (b) If 13 N is used to turn the screwdriver, what force is used to drive the screw into the wood? (c) If the actual resistive force is 470 N, how much energy is converted to heat by friction? (RW) **1.77 mm; 520 N; 0.0884 J**

Physics 06-06 Energy in Humans and the World   *Name: ________________________*

Energy in Humans



Human bodies (all living bodies) convert _______________

Rate of ______________________________ use is _______________ rate

- Basal _______________ rate (BMR)
- Total energy _______________ at rest
- Highest: _______________ and _______________

Table 7.4 Basal Metabolic Rates (BMR)

Organ	Power consumed at rest (W)	Oxygen consumption (mL/min)	Percent of BMR
Liver & spleen	23	67	27
Brain	16	47	19
Skeletal muscle	15	45	18
Kidney	9	26	10
Heart	6	17	7
Other	16	48	19
Totals	85 W	250 mL/min	100%

Table 7.5 Energy and Oxygen Consumption Rates[2] (Power)

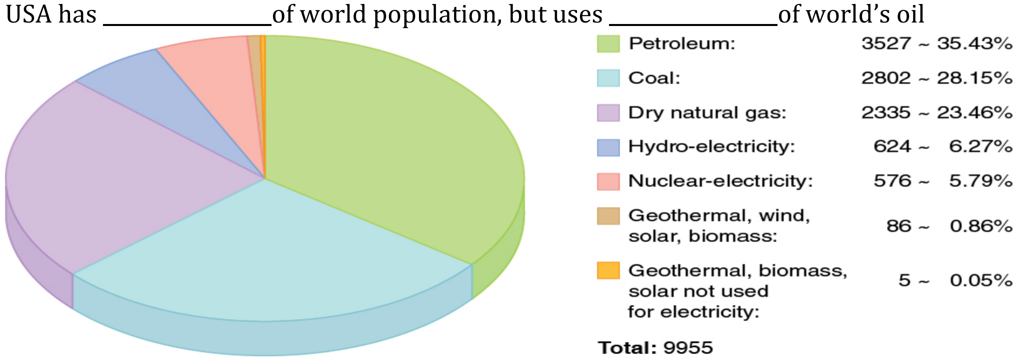
Activity	Energy consumption in watts	Oxygen consumption in liters O_2/min
Sleeping	83	0.24
Sitting at rest	120	0.34
Standing relaxed	125	0.36
Sitting in class	210	0.60
Walking (5 km/h)	280	0.80
Cycling (13–18 km/h)	400	1.14
Shivering	425	1.21
Playing tennis	440	1.26
Swimming breaststroke	475	1.36
Ice skating (14.5 km/h)	545	1.56
Climbing stairs (116/min)	685	1.96
Cycling (21 km/h)	700	2.00
Running cross-country	740	2.12
Playing basketball	800	2.28
Cycling, professional racer	1855	5.30
Sprinting	2415	6.90

World Energy Use

Energy is required to do _______________

World wide, the most common source of energy is _______________

USA has _______________of world population, but uses _______________of world's oil

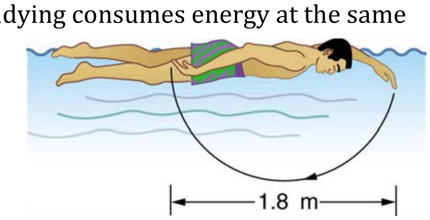


World energy consumption continues to _______________ quickly

- Growing economies in _______________ and _______________
- ______________________________ are very polluting
- Many countries trying to develop _______________ energy like _______________ and _______________
- Generally, _______________ energy use per capita = better _______________ of living

Practice Work

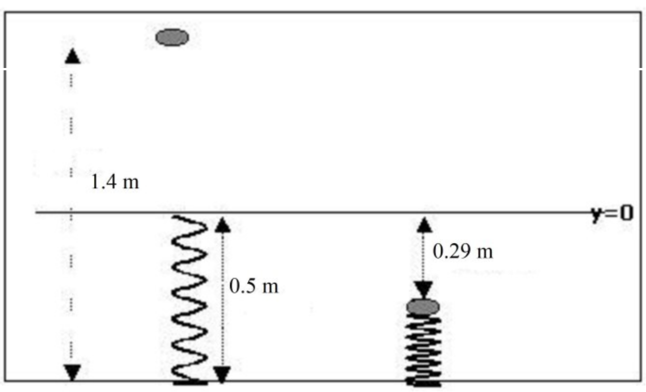
1. Explain why it is easier to climb a mountain on a zigzag path rather than one straight up the side. Is your increase in gravitational potential energy the same in both cases? Is your energy consumption the same in both?
2. Discuss the relative effectiveness of dieting and exercise in losing weight, noting that most athletic activities consume food energy at a rate of 400 to 500 W, while a single cup of yogurt can contain 1360 kJ (325 kcal). Specifically, is it likely that exercise alone will be sufficient to lose weight? You may wish to consider that regular exercise may increase the metabolic rate, whereas protracted dieting may reduce it.
3. What is the difference between energy conservation and the law of conservation of energy? Give some examples of each.
4. (a) What is the power output in watts and horsepower of a 70.0-kg sprinter who accelerates from rest to 10.0 m/s in 3.00 s? (b) Considering the amount of power generated, do you think a well-trained athlete could do this repetitively for long periods of time? (OpenStax 7.45) $\mathbf{1.17 \times 10^3}$ **W, 1.56 hp, Very high power**
5. Calculate the power output in watts and horsepower of a shot-putter who takes 1.20 s to accelerate the 7.27-kg shot from rest to 14.0 m/s, while raising it 0.800 m. (Do not include the power produced to accelerate his body.) (OpenStax 7.46) **641 W, 0.860 hp**
6. (a) What is the efficiency of an out-of-condition professor who does 2.10×10^5 J of useful work while metabolizing 500 kcal of food energy? (b) How many food calories would a well-conditioned athlete metabolize in doing the same work with an efficiency of 20%? (OpenStax 7.47) **10.0%, 251 kcal**
7. Energy that is not utilized for work or heat transfer is converted to the chemical energy of body fat containing about 39 kJ/g. How many grams of fat will you gain if you eat 10,000 kJ (about 2500 kcal) one day and do nothing but sit relaxed for 16.0 h and sleep for the other 8.00 h? Use data from Table 7.5 for the energy consumption rates of these activities. (OpenStax 7.48) **10.5 g**
8. Using data from Table 7.5, calculate the daily energy needs of a person who sleeps for 7.00 h, walks for 2.00 h, attends classes for 4.00 h, cycles for 2.00 h, sits relaxed for 3.00 h, and studies for 6.00 h. (Studying consumes energy at the same rate as sitting in class.) (OpenStax 7.49) **3800 kcal**
9. The swimmer shown in Figure 7.44 exerts an average horizontal backward force of 80.0 N with his arm during each 1.80 m long stroke. (a) What is his work output in each stroke? (b) Calculate the power output of his arms if he does 120 strokes per minute. (OpenStax 7.56) **144 J, 288 W**



10. Review: A toy gun uses a spring with a force constant of 300 N/m to propel a 10.0-g steel ball. If the spring is compressed 7.00 cm and friction is negligible: (a) How much force is needed to compress the spring? (b) To what maximum height can the ball be shot? (c) At what angles above the horizontal may a child aim to hit a target 3.00 m away at the same height as the gun? (d) What is the gun's maximum range on level ground? (OpenStax 7.63) **−21.0 N, 7.50 m, 5.77°, 84.23°, 15.0 m**
11. Review: (a) What force must be supplied by an elevator cable to produce an acceleration of 0.800 m/s^2 against a 200-N frictional force, if the mass of the loaded elevator is 1500 kg? (b) How much work is done by the cable in lifting the elevator 20.0 m? (c) What is the final speed of the elevator if it starts from rest? (d) How much work went into thermal energy? (OpenStax 7.64) $\mathbf{1.61 \times 10^4}$ **N,** $\mathbf{3.22 \times 10^5}$ **J, 5.66 m/s,4.00 kJ**

Physics Unit 6: Energy Review

1. Know about work, power, kinetic energy, gravitational potential energy, spring potential energy, Law of Conservation of Energy, simple machines, ideal mechanical advantage, efficiency, which human systems use more energy, where most of our energy comes from
2. Kelly is cutting the grass using a human-powered lawn mower. He pushes the mower with a force of 50 N directed at an angle of 35° below the horizontal direction. Calculate the work that Kelly does on the mower in pushing it 25 m across the yard.
3. A warehouse worker uses a forklift to lift a pallet of veggie dogs on a platform to a height 5 m above the floor. The combined mass of the platform and the pallet is 200 kg. If the power expended by the forklift is 1500 W, how long does it take to lift the pallet?
4. What power is needed to lift a 6000-kg elephant a vertical distance of 2 m in 30 s?
5. A 0.624-kg basketball is 3 m in the air and traveling at 5 m/s. What is the kinetic energy of the ball?
6. A 500-kg car is lifted vertically 3 meters from the surface of the earth. What is the change in the gravitational potential energy of the car?
7. A 0.624-kg basketball is 3 m in the air and traveling at 5 m/s. What is the potential energy of the ball?
8. A spring stores 50 J of energy when compressed 2 cm. What is its spring constant?
9. An engineer is asked to design a playground slide such that the speed a child, starting from rest, reaches at the bottom does not exceed 3 m/s. Determine the maximum height that the slide can be. Ignore friction.
10. A 0.80-kg hockey puck was tipped straight up at 20 m/s. How fast is it going when it accidently hits the scoreboard at 5 m above?
11. A ball of mass 0.5-kg is dropped from a height of 1.4 m (from the ground) onto a massless spring (the spring has an equilibrium length of 0.5 m). The ball compresses the spring by an amount of 0.29 m by the time it comes to a stop. Calculate the spring constant of the spring.



12. Imagine that the stone David used against Goliath has a mass of 0.50 kg and was launched at 20.0 m/s from a height of 1.20 m. How much energy did air resistance absorb if the stone was moving at 18.8 m/s when it hit Goliath's forehead at 2.0 m above the ground?
13. The kinetic energy of a car is 2×10^6 J as it travels along a horizontal road. How much work is required to stop the car in 15 s?
14. What is the ideal mechanical advantage of a pulley supporting the load with 5 ropes?
15. If the ideal mechanical advantage of an inclined plane is 2.25 and the height of the inclined plane is 1.5 m, what is the length of the inclined plane?

Physics Unit 6: Energy Review

Answers

2. $W = Fd\cos\theta$
$W = (50\,N)(25\,m)\cos 35°$
$\boldsymbol{W = 1020\,J}$
3. $P = \frac{W}{t}$
$W = PE = mgh$
$1500\,W = \frac{(200\,kg)\left(9.8\frac{m}{s^2}\right)(5\,m)}{t}$
$t(1500\,W) = 9800\,J$
$\boldsymbol{t = 6.53\,s}$
4. $P = \frac{W}{t}$
$W = PE = mgh$
$P = \frac{(6000\,kg)\left(9.8\frac{m}{s^2}\right)(2\,m)}{30\,s}$
$\boldsymbol{P = 118{,}000\,W}$
5. $KE = \frac{1}{2}mv^2$
$KE = \frac{1}{2}(0.624\,kg)\left(5\frac{m}{s}\right)^2$
$\boldsymbol{KE = 7.8\,J}$
6. $PE = mgh$
$PE = (500\,kg)\left(9.8\frac{m}{s^2}\right)(3\,m)$
$\boldsymbol{PE = 14{,}700\,J}$
7. $PE = mgh$
$PE = (0.624\,kg)\left(9.8\frac{m}{s^2}\right)(3\,m)$
$\boldsymbol{PE = 18.3\,J}$
8. $PE_{spring} = \frac{1}{2}kx^2$
$50\,J = \frac{1}{2}k(0.02\,m)^2$
$\boldsymbol{k = 250{,}000\frac{N}{m}}$
9. $E_0 + W = E_f$
External work is zero
$PE_0 = KE_f$
$mgh_0 = \frac{1}{2}mv_f^2$
$gh_0 = \frac{1}{2}v_f^2$
$\left(9.8\frac{m}{s^2}\right)h_0 = \frac{1}{2}\left(3\frac{m}{s}\right)^2$
$\boldsymbol{h_0 = 0.459\,m}$
10. $E_0 + W = E_f$
External work is zero
$KE_0 = PE_f + KE_f$
$\frac{1}{2}mv_0^2 = mgh_f + \frac{1}{2}mv_f^2$
$\frac{1}{2}v_0^2 = gh_f + \frac{1}{2}v_f^2$
$\frac{1}{2}\left(20\frac{m}{s}\right)^2 = \left(9.8\frac{m}{s^2}\right)(5\,m) + \frac{1}{2}v_f^2$
$200\,J = 49\,J + \frac{1}{2}v_f^2$
$151\,J = \frac{1}{2}v_f^2$
$302\,J = v_f^2$
$\boldsymbol{v_f = 17.4\frac{m}{s}}$
11. $E_0 + W = E_f$
External work is zero
$PE_0 = PE_f + PE_{spring}$
$mgh_0 = mgh_f + \frac{1}{2}kx^2$
$(0.5\,kg)\left(9.8\frac{m}{s^2}\right)(1.4\,m) = (0.5\,kg)\left(9.8\frac{m}{s^2}\right)(0.5\,m - 0.29\,m) + \frac{1}{2}k(0.29\,m)^2$
$6.86\,J = 1.029\,J + (0.04205\,m^2)k$
$5.831\,J = (0.04205\,m^2)k$
$\boldsymbol{k = 139\frac{N}{m}}$
12. $E_0 + W = E_f$
External work is from air resistance ≠ 0
$PE_0 + KE_0 + W_{air} = PE_f + KE_f$
$mgh_0 + \frac{1}{2}mv_0^2 + W_{air} = mgh_f + \frac{1}{2}mv_f^2$
$(0.5\,kg)\left(9.8\frac{m}{s^2}\right)(1.20\,m) + \frac{1}{2}(0.5\,kg)\left(20\frac{m}{s}\right)^2 + W_{air} = (0.5\,kg)\left(9.8\frac{m}{s^2}\right)(2\,m) + \frac{1}{2}(0.5\,kg)\left(18.8\frac{m}{s}\right)^2$
$105.88\,J + W_{air} = 98.16\,J$
$\boldsymbol{W_{air}} = -7.72\,J$ or $\boldsymbol{7.72\,J}$
13. $E_0 + W = E_f$
$KE_0 + W = 0$
$2\times 10^6\,J + W = 0$
$\boldsymbol{W = -2\times 10^6\,J}$
14. $\boldsymbol{IMA} = N = \boldsymbol{5}$
15. $IMA = \frac{L}{h}$
$2.25 = \frac{L}{1.5\,m}$
$\boldsymbol{L = 3.38\,m}$