1. How much work (energy) is needed to lift an object that weighs 200 N to a height of 4 m?

2. What is the power output of an engine that does 60,000 J of work in 10 s?

3. How much power is needed to lift the 200 N object to a height of 4 m in 4 s?

4. On a ski weekend in Colorado, Bob, whose mass is 75.0 kg, skis down a hill that is inclined at an angle of 15.0° to the horizontal and has a vertical rise of 25.0 m. How much work is done by gravity on Bob as he goes down the hill?



5. A pile driver is used to drive stakes into the ground. While building a fence, Adam drops a pile driver of mass 3000 kg through a vertical distance of 8.0 m. The pile driver is opposed by a resisting force of 5.0 x 106N. How far is the stake driven into the ground on the first stroke?

6. At target practice, Diana holds her bow and pulls the arrow back a distance of 0.30 m by exerting an average force of 40.0 N. What is the potential energy stored in the bow the moment before the arrow is released?



7. The coyote, whose mass is 20.0 kg, is chasing the roadrunner when the coyote accidentally runs off the edge of a cliff and plummets to the ground 30.0 m below. What force does the ground exert on the coyote as he makes a coyote-shaped dent 0.420 m deep in the ground?

8. A 0.080 kg robin, perched on a power line 6.0 m above the ground, swoops down to snatch a worm from the ground and then returns to an 8.0 m high tree branch with his catch.

 a. By how much did the bird’s PE increase in its trip from the power line to the tree branch?

b. How would your answer have changed if the bird had flown around a bit before landing on the tree branch?

9. Blackie, a cat whose mass is 5.45 kg, is napping on top of the refrigerator when he rolls over and falls. Blackie has a KE of 85.5 J just before he lands on his feet on the floor. How tall is the refrigerator?



10. A nutcracker 16 cm long is used to crack open a Brazil nut that is placed 12 cm from where your hand is squeezing the nutcracker. What is the ideal mechanical advantage of the nutcracker?

11. Two clowns, of mass 50.0 kg and 70.0 kg respectively, are in a circus act performing a stunt with a trampoline and a seesaw. The smaller clown stands on the lower end of the seesaw while the larger clown jumps from the trampoline onto the raised side of the seesaw, propelling his friend into the air.



a. What is the ideal mechanical advantage of the seesaw?

b. If the larger clown exerts a force of 850. N on the seesaw as he jumps, how much force is exerted on the smaller clown?

12. A crate of bananas weighing 3000. N is shipped from South America to New York, where it is unloaded by a dock worker who lifts the crate by pulling with a force of 200. N on the rope of a pulley system. What is the actual mechanical advantage of the pulley system?



13. A 5.00 N salmon swims 20.0 m upstream against a current that provides a resistance of 1.50 N. This portion of the stream rises at an angle of 10.0° with respect to the horizontal.

 a. How much work is done by the salmon against the current?

b. What is the gain in PE by the salmon?

c. What is the total work that must be done by the salmon?

14. The Ramseys are moving to a new town, so they have called in the ACME moving company to take care of their furniture. Debbie, one of the movers, slides the Ramsey’s 2200 N China Cabinet up a 6.0 m long ramp to the moving van, which stands 1.0 m off the ground.

a. What it the ideal mechanical advantage of the incline?

b. If Debbie must exert a 500 N force to move the China cabinet up the ramp with a constant speed, what is the actual mechanical advantage of the ramp?

c. What is the efficiency of the ramp?

15. Elben lifts an engine out of this Volkswagen with the help of a winch that allows him to raise the engine 0.020 m for every 0.90 m he pulls on the cable. Elben expends 1000 J of energy to lift the 800 N engine 0.50 m.

 a. What is the efficiency of the winch?

 b. What is the ideal mechanical advantage of the winch?

 c. What is the actual mechanical advantage of the winch?

 d. What force does Elben exert to lift the engine?



16. Tom’s favorite pastime is fishing.

a. How much work is required for Tom to reel in a 10.0 kg bluefish from the water’s surface to the deck of a fishing boat, 5.20 m above the water, if the reel of his fishing pole is 85.0% efficient?

b. If Tom applies a force of 15 N to the reel’s crank handle, what is the actual mechanical advantage of the fishing pol?

c. What is the ideal mechanical advantage of the fishing pole?

17. The block of ice weighs 500 Newtons.



a. What is the mechanical advantage of the incline?

b. How much force is needed to push it up the incline? (Neglect friction)

1. How much work (energy) is needed to lift an object that weighs 200 N to a height of 4 m?

*W = fnet x d = 200 N x 4 m = 800 J*

2. What is the power output of an engine that does 60,000 J of work in 10 s?

*P = W / t = 60,000 J / 10 s = 6,000 Watts*

3. How much power is needed to lift the 200 N object to a height of 4 m in 4 s?

*P = W / t = (f x d) / t = (200 N x 4 m) / 4 s = 200 Watts*

4. On a ski weekend in Colorado, Bob, whose mass is 75.0 kg, skis down a hill that is inclined at an angle of 15.0° to the horizontal and has a vertical rise of 25.0 m. How much work is done by gravity on Bob as he goes down the hill?

*The angle of incline does not matter when considering the vertical component of work.*

*The work done by gravity once the skier moves is the same as the PE (mgh) before the skier moves. The skier’s weight (mg) and the vertical rise (h) equal f x d once he skies.*

*W = f x d = mgh = (75.0 kg) (10.0 m/s2) (25.0) = 18,800 J*



5. A pile driver is used to drive stakes into the ground. While building a fence, Adam drops a pile driver of mass 3000 kg through a vertical distance of 8.0 m. The pile driver is opposed by a resisting force of 5.0 x 106N. How far is the stake driven into the ground on the first stroke?

*The pile driver is a machine to make work easier (less force).*

*Before the pile driver “works” it has PE which equals the eventual work done.*

*PE represents the effort (mgh) of the pile driver.*

*Work done (f x d) on the stake represents the resistance.*

*W = f x d = mgh. Therefore, solve for “d”🡪 d = mg / f*

*d = (3000 kg) (10.0 m/s2) (8.0 m) / 5.0 x 106 N = 0.048 m*

6. At target practice, Diana holds her bow and pulls the arrow back a distance of 0.30 m by exerting an average force of 40.0 N. What is the potential energy stored in the bow the moment before the arrow is released?

*The work done (f x d) by arrow will be based on the PE (mgh) before the arrow is shot.*

*W = fnet x d = mgh = (40.0 N) (0.30 m) = 12 J*



7. The coyote, whose mass is 20.0 kg, is chasing the roadrunner when the coyote accidentally runs off the edge of a cliff and plummets to the ground 30.0 m below. What force does the ground exert on the coyote as he makes a coyote-shaped dent 0.420 m deep in the ground?

*Newton’s 3rd law shows the equal and opposite force of the coyote and the ground.*

*The work done by the ground on the coyote equals the work done by the coyote on the ground. The work done by the coyote is equal to the PE (mgh) of the coyote before he falls.*

*W = f x d = mgh. Therefore, solve for “f”🡪 f = mgh /d*

*f = (20.0 kg) (10.0 m/s2) (30.0 m) / (0.42 m) = 14,300 N*

8. A 0.080 kg robin, perched on a power line 6.0 m above the ground, swoops down to snatch a worm from the ground and then returns to an 8.0 m high tree branch with his catch.

a. By how much did the bird’s PE increase in its trip from the power line to the tree branch?

*The PE increase is based on the change in vertical distance or height (h).*

*PE = mg∆h = (0.080 kg) (10.0 m/s2) (2.0 m) = 1.6 J*

b. How would your answer have changed if the bird had flown around a bit before landing on the tree branch?

*The PE does not change unless the height changes; so, it stays the same. The change in energy is independent on the path.*

9. Blackie, a cat whose mass is 5.45 kg, is napping on top of the refrigerator when he rolls over and falls. Blackie has a KE of 85.5 J just before he lands on his feet on the floor. How tall is the refrigerator?

*The cat was falling, therefore, KE is involved, and since the KE given is at the point of hitting the floor, it is the maximum KE where velocity is greatest. The cat is falling from a height so PE is involved. The maximum KE equals the maximum PE (mgh).*

*KE = PE … KE = mgh. Therefore, solve for “h”🡪 h = KE / mg*



*h = (85.5 J) / (5.45 kg) (10.0 m/s2) = 1.57 m*

10. A nutcracker 16 cm long is used to crack open a Brazil nut that is placed 12 cm from where your hand is squeezing the nutcracker. What is the ideal mechanical advantage of the nutcracker?

*IMA = deffort / dresistance = 12cm / 4cm = 3*

11. Two clowns, of mass 50.0 kg and 70.0 kg respectively, are in a circus act performing a stunt with a trampoline and a seesaw. The smaller clown stands on the lower end of the seesaw while the larger clown jumps from the trampoline onto the raised side of the seesaw, propelling his friend into the air.



a. What is the ideal mechanical advantage of the seesaw?

*IMA = deffort / dresistance = 2.40 m / 0.80 m = 3*

b. If the larger clown exerts a force of 850. N on the seesaw as he jumps, how much force is exerted on the smaller clown?

*Assuming 100% efficiency, MA = fR / fE … rearrange to solve for fE … fE = MA / fR*

*OR*

*Assume 100% efficient (which doesn’t really happen), meaning work input equals work output.*

*Winput / Woutput = finput x dinput / foutput x doutput*

*Therefore, solve for “foutput”🡪 finput x dinput / doutput*

*foutput = (850. N) (2.40 m) / 0.80 m = 2550 N*

12. A crate of bananas weighing 3000. N is shipped from South America to New York, where it is unloaded by a dock worker who lifts the crate by pulling with a force of 200. N on the rope of a pulley system. What is the actual mechanical advantage of the pulley system?



*AMA = fresistance / feffort or fout / fin*

*AMA = 3000. N / 200. N = 15.0*

*The pulley exerts 15.0 times more force on the crate than the dock worker exerts to pull the rope. Notice that mechanical advantage has no units. Plus, the trade-off would be that the dock worker has to pull the rope a much greater distance.*

13. A 5.00 N salmon swims 20.0 m upstream against a current that provides a resistance of 1.50 N. This portion of the stream rises at an angle of 10.0° with respect to the horizontal.

 a. How much work is done by the salmon against the current?

h

10°

20.0 m

*W = fnet x d = 1.50 N x 20.0 m = 30.0 J*

b. What is the gain in PE by the salmon?

*The PE increase is based on the change in distance or height (h).*

*The salmon’s weight equals “mg” and the change in height can be calculated using the right triangle as shown … sin 10.0 = h / 20.0 m; therefore, h = 20.0 m x sin 10.0*

*PE = mgh = (5.0 N) (20.0 m) (sin 10.0) = 17.4 J*

c. What is the total work that must be done by the salmon?

*The total work done by the salmon is the sum of the work done against the current and the work done by swimming the height of the stream. In other words, the PE of the stream.*

*Wtotal = Wsalmon + PEstream = 30.0 J + 17.4 J = 47.4 J*

 d. If the salmon takes 40.0 s to swim the distance, what power does it exert in doing so?

*P = W / t = 47.4 J / 40.0 s = 1.19 Watts*

14. The Ramseys are moving to a new town, so they have called in the ACME moving company to take care of their furniture. Debbie, one of the movers, slides the Ramsey’s 2200 N China Cabinet up a 6.0 m long ramp to the moving van, which stands 1.0 m off the ground.

a. What it the ideal mechanical advantage of the incline?

 *IMA = deffort / dresistance = length / height = 6.0 m / 1.0 m = 6*

b. If Debbie must exert a 500 N force to move the China cabinet up the ramp with a constant speed, what is the actual mechanical advantage of the ramp?

 *AMA = fresistance / feffort = 2200 N / 500 N = 4.4*

c. What is the efficiency of the ramp?

 *Eff = AMA / IMA x 100% = 4.4 / 6 = 73 %*

*Eff = Wout / Win = 2200 N x 1.0 m / 500 N x 6.0 m = 73 %*

15. Elben lifts an engine out of this Volkswagen with the help of a winch that allows him to raise the engine 0.020 m for every 0.90 m he pulls on the cable. Elben expends 1000 J of energy to lift the 800 N engine 0.50 m.

 a. What is the efficiency of the winch?

*Eff = Wout / Win= foutput x doutput / finput x dinput = 800. N x 0.50 m / 1000 N = 0.40 = 40 %*

 b. What is the ideal mechanical advantage of the winch?

*IMA = deffort / dresistance = din / dout = 0.90 m / 0.020 m = 45*

 c. What is the actual mechanical advantage of the winch?

*Based on the Efficiency (Eff = AMA / IMA), we can solve for AMA.*

*AMA = IMA / Eff = 45 x 0.40 = 18*

 d. What force does Eiben exert to lift the engine?

*AMA = fresistance / feffort. Therefore, solve for effort force (force “in”)*

*feffort = fresistance / AMA = 800. N / 18N = 44 N*



16. Tom’s favorite pastime is fishing.

a. How much work is required for Tom to reel in a 10.0 kg bluefish from the water’s surface to the deck of a fishing boat, 5.20 m above the water, if the reel of his fishing pole is 85.0% efficient?

*Eff = Wout / Win = foutput x doutput / finput x dinput. Solve for work input.*

*Win = Wout /Eff =finput x dinput / foutput x doutput / Eff*

*Win = (10.0 kg) (10.0 m/s2) (5.20 m) / (0.850) = 612 J*

b. If Tom applies a force of 15 N to the reel’s crank handle, what is the actual mechanical advantage of the fishing pol?

*AMA = fresistance / feffort = 100. N / 15 N = 6.7*

c. What is the ideal mechanical advantage of the fishing pole?

*Based on the Efficiency (Eff = AMA / IMA), we can solve for IMA.*

*IMA = AMA / Eff = 6.7 / 0.850 = 7.9*

17. The block of ice weighs 500 Newtons.



a. What is the mechanical advantage of the incline?

*MA = deffort / dresistance = 6m / 3 m = 2*

b. How much force is needed to push it up the incline? (neglect friction)

*Assuming 100% efficiency, MA = fR / fE … rearrange to solve for fE … fE = MA / fR*

*OR*

*Work output = work input. Therefore, the work done on the block by the person is equal to the work done by the block (PE = mgh).*

*Woutput = 500 N x 3 m = 1500 J = feffort x deffort*. Solving for effort force 🡪

*feffort = Woutput / deffort* *= 1500 J / 6 m = 250 N*

*Notice that the effort required is half the resistance load, but the distance is twice as much.*