Work

1. Determine the work done in each of the following cases:
   a. Kicking a soccer ball forward with a force of 40 N over a distance of 15 cm
   b. Lifting a 50-kg barbell straight up 1.95 m
   c. Pulling a sled with a force of 120 N at an angle of 25° to the horizontal if the sled is displaced 4.0 m forward

2. A tow truck pulls a 3.00 x 10^3 kg car from rest with a horizontal force of 5.00 x 10^3 N. The truck and car accelerate at 2.5 m/s^2 for 5.0 s to reach the speed limit of 45 km/h. How much work is done by the tow truck?

3. A wheelbarrow is pushed by a force of 78 N [U35°R] over a distance of 10 m. Determine the work done to move the wheelbarrow along the ground.

4. A 52 000-kg train slows from 25 m/s to 14 m/s in 5.0 s. Calculate the work done on the train.

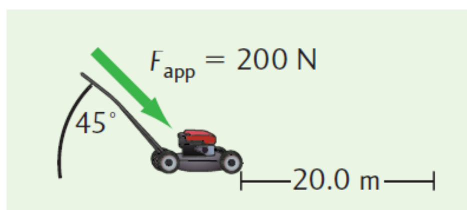
5. Give three examples where a force is exerted but no work is done.

6. How much work is done on a 750-kg load of bricks by a bricklayer if he carried the bricks upward to a height of 8.2 m to repair a chimney?

7. If the bricklayer in Problem 6 decided to use a motor-driven rope lift that can do 2000 J of work, what mass of bricks could be lifted to the 8.2-m height?

8. A shopper pushes a shopping cart with a force of 75 N at a constant speed of 0.75 m/s for an hour around a grocery store. How much work does he do on the cart?

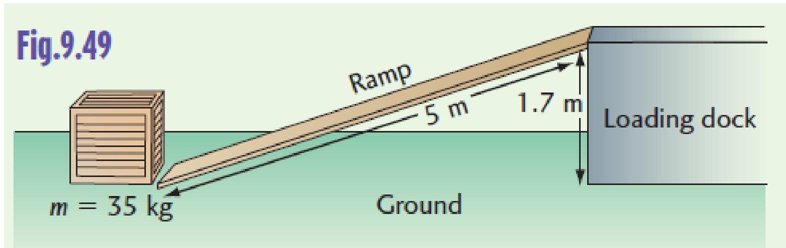
9. The school caretaker is applying a 200-N force 45° to the horizontal to push a lawn mower a horizontal distance of 20.0 m. How much work does she do on the lawn mower, assuming no friction?



10. How much work is done pushing a wheelbarrow full of cement 5.3 m [forward] if a force of 5.00 x 10^2 N is applied:
    a. horizontally?
    b. 20° above the horizontal?
    c. 20° from the vertical?

11. Explain what is meant by –350 J of work. Give an example.

12. A 35-kg box needs to be lifted to the top of a loading dock, which is also accessible by ramp. The ramp is 5.0 m long and has a vertical height of 1.7 m.
   a) What minimum force is required to lift the box straight up onto the loading dock?
   b) What minimum amount of work is required to lift the crate straight up onto the loading dock?
   c) What force is required to push the crate up the ramp such that the amount of work is the same as in b)? Assume no friction.



Answers

1a	6.0 J		6	6.0×10^4 J		11	notes
1b	9.6×10^2 J		7	25 kg		12a	3.4×10^2 N
1c	4.4×10^2 J		8	2.0×10^5 J		12b	5.8×10^2 N
2	1.6×10^5 J		9	2.83×10^3 J		12c	1.2×10^2 N
3	4.5×10^2 J		10a	2.7×10^3 J			
4	$- 1.1 \times 10^7$ J		10b	2.5×10^3 J			
5	Notes		10c	9.1×10^2 J			

Gravitational Energy

1. Calculate the potential energy for the following cases:
    a. A 10.0-kg mass moves up 2.40 m.
    b. A 589-mg mass moves up 325 cm.

2. What role does gravitational potential energy play in the production of hydroelectricity?

3. Muskrat Falls operates under a maximum head of about 44 m (height from which water falls). If about 2.51×10^7 kg of water falls every second, how much energy is created by the falling water?

4. How much gravitational potential energy would a 275.0-g book have if it was placed on a shelf:
    a. 2.60 m high
    b. 1.80 m high
    c. 0.30 m high

5. What percentage of its gravitational potential energy does a squash ball lose if it falls from 3.0 m and returns to a height of 0.76 m after bouncing once?

6. A cliff at the Elora Gorge is 19.6 m above the surface of the Grand River, which is 5.34 m deep. What is a 70.0-kg cliff diver's gravitational potential energy from the top of the cliff with respect to the water's surface and with respect to the bottom of the river?

7. A 1.00-kg book falls 0.75 m from a desk to the floor. How much potential energy did the book lose?

8. Calculate the gravitational potential energy of
    a. a 2.0-kg physics textbook sitting on your desk 1.3 m above the floor.
    b. a 50-g egg dropped from the top of a 3.0-m-high chicken coup.
    c. a 200-kg air glider flying 469 m above the ground.
    d. a 5000-kg car parked on the road.

9. A forklift requires a force of 4410 N to lift a roll of steel 3.5 m.
    a. What is the mass of the steel?
    b. How much work is required to lift the steel?

1a	235 J		5	75%		8a	25 J
1b	0.0188 J		6a	1.34×10^4 J		8b	1.5 J
2	notes		6b	1.71×10^4 J		8c	9.2×10^5 J
3	1.1×10^{10} J		7	7.4 J		8d	0 J
4a	7.00 J					9a	4.5×10^2 kg
4b	4.85 J					9b	1.5×10^4 J
4c	0.81 J						

Kinetic Energy

1. Calculate the kinetic energy or the change in kinetic energy for the following cases involving a mass of 2.0 kg:
   a. The mass moves at 4.0 m/s.
   b. The mass moves at 20 km/h.
   c. The mass **increases** its speed from 2.0 m/s to 5.5 m/s.

2. What is the kinetic energy of a 60.0-g tennis ball that is travelling at:
   a) 10.0 m/s b) 25.0 m/s

3. What is the mass of an object that is travelling at 10.0 m/s with a kinetic energy of 370 J?

4. A 37.0-g arrow is shot from a crossbow at 234.0 km/h. What is the arrow's kinetic energy?

5. A 2000-kg truck is travelling at 80 km/h. What is the kinetic energy of the truck?

6. What speed would the truck in Problem 5 have if its kinetic energy was cut in half by applying the brakes?

7. At what speed must a 250.0-kg motorcycle be travelling to have a kinetic energy of:
   a) 2.8×10^4 J? b) 1.12×10^5 J?

8. Calculate the kinetic energy of:
   a. 45-kg sprinter running at 10 m/s.
   b. 2.0-g fly buzzing around your head every second. (radius of 10 cm.)
   c. 15 000-kg army tank charging forward at 100 km/h.

9. A really big fish swimming horizontally and nibbling the end of your barbless hook has a kinetic energy of 450 J. You notice that 5.0 m of line is released every 2.0 s. Calculate the mass of the fish.

10. Calculate the velocity of a 1.2-kg falling star (meteorite) with 5.5×10^8 J of energy.

11. A 15-kg mass is released from rest at a height of 200 m. If air resistance is negligible, determine the kinetic energy of the mass after it has fallen 199 m. What force does work here?

1a	16 J		5	4.9×10^5 J		9	1.4×10^2 kg
1b	31 J		6	54 km/hr		10	3.0×10^4 m/s
1c	$\Delta E_k = +26$ J		7a	15 m/s		11	2.9×10^4 J
2a	3.00 J		7b	30.0 m/s			
2b	18.8 J		8a	2.3×10^3 J			
3	7.40 kg		8b	3.9×10^{-4} J			
4	78.2 J		8c	5.8×10^6 J			

Work - Energy Theorem

1. How much work is done by an Olympic triathlete who accelerates herself on her bicycle (a combined mass of 105 kg) from 5.0 m/s to 10.0 m/s?

2. A 15-g bullet strikes a metal plate on an armoured car at a speed of 350 m/s. The bullet penetrates the armour 3.3 mm before coming to a stop.

   a) Calculate the average net force acting on the bullet while it is in the metal.
   b) Calculate the average force exerted on the metal by the bullet.

3. A thin 200.0 g arrow moving horizontally at 125 m/s strikes a 1.0 kg apple, initially at rest. The arrow pierces the apple in a negligible time, emerging from it with a velocity of 100 m/s.
   a) What is the initial kinetic energy of the arrow?
   b) What is the final kinetic energy of the arrow?
   c) What is the **change** in kinetic energy of the arrow?
   d) How much work does the arrow do to the apple?

4. A 50.0 kg crate is sliding on the floor.
   a) How much work is required to change the velocity of a 50.00 kg crate from 5.00 m/s to 7.0 m/s?
   b) What average force is required if it is accomplished over a distance of 2.50 m?

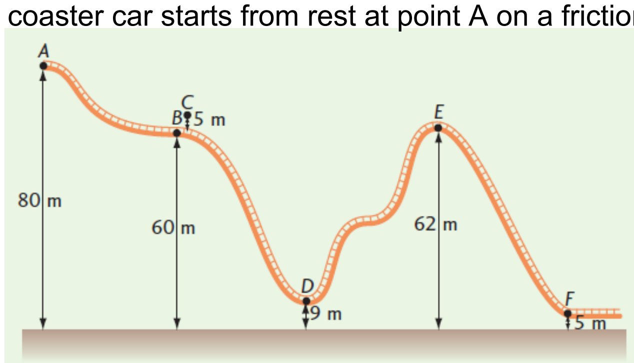
5. A 1300 kg car is moving to the right at 30.0 m/s when the driver applies the brakes, which apply a stopping force of 8.1×10^3 N. If the brakes are applied over a distance of 68.0 m, what will be the final speed of the car?

1	3.9×10^3 J		4a	6.00×10^2 J			
2a	$- 2.8 \times 10^5$ N		4b	240 N			
2b	$+ 2.8 \times 10^5$ N		5	7.33 m/s			
3a	1.56×10^3 J						
3b	1.00×10^3 J						
3c	- 563 J						
3d	- 563 J						

Total Mechanical Energy

1. For the case of a rock thrown down from a cliff, calculate the following. Assume the rock is 6.5 kg and moving at 18 m/s **down** at the time it was thrown from a 120-m-high cliff.
   a) The kinetic energy at the top of the cliff
   b) The potential energy at the top of the cliff
   c) The total mechanical energy at the top of the cliff
   d) The kinetic energy of the rock halfway down
   e) The speed of the rock halfway down
   f) The speed of the rock just as it hits the ground

2. A 1000-kg roller coaster car starts from rest at point A on a frictionless track as shown.



   a) At which point on the track is the car's gravitational potential energy the greatest? the least?
   b) What is the car's maximum speed?
   c) What is the speed of the roller coaster car at point E?
   d) What constant braking force would have to be applied to bring the coaster car at point F to a stop in 5.0 m?

3. A 5.0-kg rock is dropped from a height of 92.0 m. What is the kinetic energy and the gravitational potential energy when the rock is 40.0 m from the ground?

4. A ball of mass 240.0 g is moving through the air at 20.0 m/s with a gravitational potential energy of 70.0 J. With what speed will the ball hit the ground?

1a	1.1×10^3 J		2a	A,F		4	31.4 m/s
1b	7.7×10^3 J		2b	38 m/s			
1c	8.7×10^3 J		2c	19 m/s			
1d	4900 J		2d	1.4×10^5 N			
1e	39 m/s		3	$E_k = 2.5 \times 10^3$J			
1f	52 m/s			$E_g = 2.0 \times 10^3$J			

Efficiency Practice

1. A water pump is run by an electric motor with an input of 752 J/s. It is used to pump water from a reservoir up to a height of 37.0 m and into a water tower at a rate of 1.48 kg of water per second.
   a) Assuming a time of 1.0 s, what is the useful energy output, E_{OUT}? (536 J)
   b) How much energy does the water pump actually use in 1.0 s, E_{IN}?
   c) What is the efficiency of the water pump?

2. A karate blow can transfer 35.0 J of total energy to kinetic energy. If this transfer is only 25% efficient, what maximum velocity can the 70.0-kg target ever reach? 0.50 m/s

3. Several students in an auto shop class need to lift an engine out of a car using a rope and pulley system. The mass of the engine is 170.0 kg. By pulling as a team, the students can exert a force of about 1.72×10^3 N to lift the engine to the necessary height of 2.20 m.
   a) How much “useful work” was done by the students?
   b) How much work was done in total to lift the engine?
   c) What was the overall efficiency of the students in lifting the engine?
   d) One of the students recommends that all of her friends who helped lift the engine should receive a final grade equal to their percent efficiency. The shop teacher claims that this would be unfair to the students because none of them could ever achieve 100% efficiency. Explain.

4. A 2.0 kg cart is pulled up a 3.0 m high ramp with a force of 19 N at a constant speed. If the cart is pulled a distance of 5.0 m up the ramp, calculate the percent efficiency of the ramp.

5. What is the efficiency of a crane that uses 4.10×10^5 J of energy to lift a 1.00×10^3 kg load a vertical height of 32.0 m?

6. A 49.0 kg child sits on the top of a slide that is located 1.80 m above the ground. After his descent, the child reaches a velocity of 3.00 m/s at the bottom of the slide. Calculate how efficiently the gravitational potential energy is converted to kinetic energy.

7. A machine requires 580 J to do 110 J of useful work. How efficient is the machine?

8. An incandescent light bulb transforms 120 J of electrical energy to produce 5 J of light energy. A fluorescent bulb requires 60 J of electrical energy to produce the same amount of light. Calculate the efficiency of each type of bulb

1a	536 J		4	62.0%
1b	752 J		5	76.6%
1c	71.2 %		6	25.5%
2	0.50 m/s		7	19.0%
3a	3.66×10^3 J		8	4%, 8%
3b	3.78×10^3 J			
3c	96.8%			
3d	Notes			

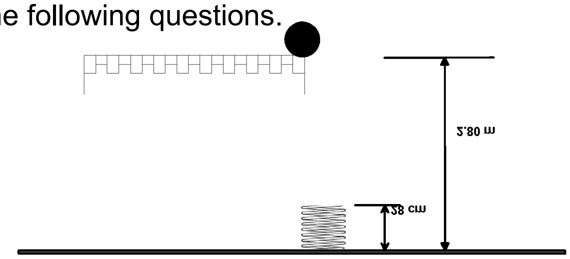
Power

1. If a hair dryer does 3000 J of work to heat the air every two seconds, what is its power?
2. How much electrical energy is used by a 100-W light bulb if it was accidentally left on for 8.0 h?
3. A snow blower does 1.8×10^6 J of work in 0.600 h. What is its power?
4. How long would it take a 1.00-kW electric motor on a conveyor belt to do 750 J of work?
5. A 613.0-kg mass is placed on a forklift that can generate 950 W of power. What is the constant speed of the forklift while lifting this load?
6. Water is pumped up to a water tower, which is 92.0 m high. The flow rate up to the top of the tower is 75 L/s and each litre of water has a mass of 1.00 kg. What power is required to keep up this flow rate to the tower?

1	1.50×10^3 W		4	0.750 s
2	2.9×10^6 J		5	0.158 m/s
3	8.3×10^2 W		6	6.8×10^4 W

Hooke's Law and Elastic Potential Energy

1. A 5.63 kg bowling ball is dropped from a shelf that is 2.80 m high. The ball lands on an uncompressed spring that is normally 28 cm long and has a spring constant of 17303 N/m. Answer the following questions.



a. What is the gravitational potential energy of the ball (relative to the floor) before it falls? (154 J)
b. Just before the spring starts to compress, the ball is moving with a speed of 7.03 m/s. What is the kinetic energy and gravitational potential energy of the ball just before the spring starts to compress? (E_g = 15.4 J, E_k = 139 J)
c. The spring compresses and brings the ball to a stop. The elastic potential energy stored in the spring is then 146.2 J. How much did the spring compress? (0.130 m)

Simple Harmonic Motion

1. Given a mass-spring system with a bob of mass 0.485 kg, a spring constant of 33 N/m, and an initial displacement of 0.23 m, determine:

a) The kinetic energy of the bob as it passes the equilibrium point (0.87 J)

b) The bob's speed as it passes the equilibrium point (1.9 m/s)

2. A 2.0 kg mass on a spring is extended 0.30 m from the equilibrium position and released. The spring has a constant of 65 N/m.

a) What is the initial potential energy of the spring? (2.9 J)

b) What maximum speed does the spring reach? (1.7 m/s)

c) Find the speed of the mass when the displacement is 0.20 m. (1.3 m/s)

d) What is the maximum acceleration of the mass? (9.8 m/s^2)

e) What is the acceleration of the mass when the displacement is 0.20 m? (6.5 m/s^2)

3. A 100.0 kg mass is dropped from 12 m onto a spring, causing the spring to recoil 0.64 cm. What is the spring constant? (5.7×10^8 N/m)

4. What force is required to deform a spring with a spring constant of 1250 N/m by 2.5 cm? (31 N)

5. A mass of 3.5 kg is hanging from a spring which deforms by 21.2 cm. What is the spring constant k? (162 N/m)

6. How much energy is stored in the spring from problem 1? (0.39 J)

7. How much would you have to deflect a spring with k = 768 N/m to store 86 J of energy? (0.47 m)

8. A 2.5 kg mass is released from a height of 1.7 m onto a spring with k = 845 N/m. By how much will the spring deflect? (0.31 m)

9. A 4.0 kg mass is held against a spring with a spring constant of 420 N/m and deflected by 12.0 cm. The block is then released.
   a) What is the kinetic energy of the block after it leaves the spring? (3.0 J)
   b) How fast is it going when it is just released? (1.2 m/s)
   c) If the block hits a rough patch μ_k = 0.456 how far will it go before it stops? (0.17 m)

10. A 25.0 kg mass is moving at 1.5 m/s when it contacts a spring and deflects it by 34 cm. What is the spring constant k of the spring? (487 N/m)

11. A 2.3 kg mass-spring system is oscillating in simple harmonic motion. If the spring has a spring constant of 12000 N/m and a max deformation of 16.2 cm, calculate:
    a) magnitude of the max acceleration (845 m/s^2)
    b) magnitude of the acceleration at the equilibrium position (0 m/s^2)

12. A 4.0 kg mass is undergoing SHM on a horizontal spring with k = 1500 N/m. The mass is deflected 0.15 m and released.
    a) What is the magnitude of the max acceleration of the spring? (56 m/s^2)
    b) What is the total energy of this system? (16.9 J)
    c) What is the magnitude of the acceleration of the system when x = 0.08 m? (30 m/s^2)
    d) What is the speed of the mass when x = 0.08 m? (2.5 m/s)
    e) How fast is the mass going as it passes the equilibrium point? (2.9 m/s)

13. A 6.0 kg mass is hung from a spring on a tree and the spring deflects by 0.175 m. The spring is then removed and attached to a 1.4 kg mass. This mass is pulled 25 cm horizontally and released.
    a) What is the magnitude of the maximum acceleration of the mass? (6.0×10^1 m/s^2)
    b) How fast is the mass going when the deflection is only 18 cm? (2.7 m/s)

__Elastic and Inelastic Collisions__

1. A student on a skateboard, with a combined mass of 78.2 kg, is moving east at 1.60 m/s. As he goes by, the student skilfully scoops his 6.4-kg backpack from the bench where he had left it. What will be the velocity of the student immediately after the pickup? Is this collision elastic or inelastic? Justify your answer.

2. A 1050-kg car at an intersection has a velocity of 2.65 m/s [N]. The car hits the rear of a stationary truck, and their bumpers lock together. The velocity of the car-truck system immediately after collision is 0.78 m/s [N]. What is the mass of the truck? Is this collision elastic or inelastic? Justify your answer.

3. A 0.25-kg volleyball is flying west at 2.0 m/s when it strikes a stationary 0.58-kg basketball dead centre. The volleyball rebounds east at 0.79 m/s. What will be the velocity of the basketball immediately after impact? Is this collision elastic or inelastic? Justify your answer.

4. A 9.50 kg toy flatcar moving forward at 0.70 m/s strikes a stationary 18 kg boxcar, causing it to move forward at 0.48 m/s. What will be the velocity of the flatcar immediately after collision if they fail to connect? Is this collision elastic or inelastic? Justify your answer.

5. A 72-kg snowboarder gliding at 1.6 m/s [E] bounces west at 0.84 m/s immediately after colliding with an 87-kg skier travelling at 1.4 m/s [W]. What will be the velocity of the skier just after impact? Is this collision elastic or inelastic? Justify your answer.

6. A 125-kg bighorn ram butts heads with a younger 122-kg ram during mating season. The older ram is rushing north at 8.50 m/s immediately before collision, and bounces back at 0.11 m/s [S]. If the younger ram moves at 0.22 m/s [N] immediately after collision, what was its velocity just before impact? Is this collision elastic or inelastic? Justify your answer.

1	1.5 m/s		Inelastic	E_{K1} = 100 J, E_{K2} = 95 J
2	2.5 x 10^3 kg		Inelastic	E_{K1} = 3680 J, E_{K2} = 1079 J
3	1.2 m/s [W]		Elastic	E_{K1} = 0.50 J, E_{K2} = 0.50 J
4	0.22 m/s [backward]		Elastic	E_{K1} = 2.3 J, E_{K2} = 2.3 J
5	0.62 m/s [E]		Inelastic	E_{K1} = 180 J, E_{K2} = 42 J
6	8.6 m/s [S]		Inelastic	E_{K1} = 9000 J, E_{K2} = 3.7 J

Radiation

Fill in the table of information on each of these nuclides:

Atomic symbol	Atomic number	Mass number	Protons	Neutrons	Electrons
B				6	
	11	24			
			31	37	
		89			39
	29			35	
		100	43		
Pb		207			
				102	70
		225	89		
Mo				53	
	81	206			
	100			159	
No		261			
Yb		172			
			106	159	

Answers:

Atomic symbol	Atomic number	Mass number	Protons	Neutrons	Electrons
B	5	11	5	6	5
Na	11	24	11	13	11
Ga	31	68	31	37	31
Y	39	89	39	50	39
Cu	29	64	29	35	29
Tc	43	100	43	57	43
Pb	82	207	82	125	82
Yb	70	172	70	102	70
Ac	89	225	89	136	89
Mo	42	95	42	53	42
Tl	81	206	81	125	81
Fm	100	259	100	159	100
No	102	261	102	159	102
Yb	70	172	70	102	70
Sg	106	265	106	159	106

Natural Transmutations

1. Write the correct nuclide symbol(s) for each.

a	Alpha Particle		f	Beta$^-$	
b	Beta$^+$		g	Gamma Ray	
c	Electron		h	Positron	
d	β^-		I	β^+	
e	α		j	γ	

2. Identify each particle.

a	${}^{0}_{1}e$		d	${}^{0}_{-1}e$	
b	${}^{4}_{2}He$		e	α	
c	β^-		f	B^+	

3. Identify each transmutation as either α, β^-, β^+, or γ

a	${}^{238}_{92}\mathrm{U} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{234}_{90}\mathrm{Th}$		d	${}^{125}_{53}\mathbf{I}^{*} \longrightarrow {}^{125}_{53}\mathbf{I} + \gamma$	
b	${}^{234}_{90}\mathrm{Th} \rightarrow {}^{0}_{-1}\mathrm{e} + {}^{234}_{91}\mathrm{Pa}$		e	${}^{235}_{92}\mathrm{U} \longrightarrow {}^{0}_{0}\gamma + {}^{235}_{92}\mathrm{U}$	
c	${}^{14}_{6}\mathrm{C} \rightarrow {}^{0}_{-1}\mathrm{e} + {}^{14}_{7}\mathrm{N}$		f	${}^{11}_{6}C \rightarrow +{}^{0}_{+1}\beta + {}^{11}_{5}B$	

4. Identify the missing nuclide.

a) ${}^{4}_{2}\mathrm{He} + \_\_ \rightarrow {}^{17}_{8}\mathrm{O} + {}^{1}_{1}\mathrm{H}$
b) $\_\_ + {}^{10}_{5}\mathrm{B} \rightarrow {}^{7}_{3}\mathrm{Li} + {}^{4}_{2}\mathrm{He}$
c) ${}^{2}_{1}\mathrm{H} + {}^{200}_{80}\mathrm{Hg} \rightarrow {}^{198}_{79}\mathrm{Au} + \_\_$
d) ${}^{15}_{8}\mathrm{O} \rightarrow {}^{15}_{7}\mathrm{N} + \_\_$
e) ${}^{1}_{0}n + {}^{19}_{9}\mathrm{F} \rightarrow \_\_\ \mathrm{Ne} + {}^{0}_{-1}e$

5. For the following parent nuclei undergoing alpha decay, determine the daughter nucleus.
   a) $^{238}_{92}U$ b) $^{248}_{96}Cm$ c) $^{223}_{86}Rn$ d) $^{244}_{94}Pu$ e) $^{64}_{29}Cu$

6. For the following parent nuclei undergoing β^- decay, determine the daughter nucleus.
   a) $^{32}_{15}P$ b) $^{23}_{10}Ne$ c) $^{35}_{16}S$ d) $^{45}_{20}Ca$ e) $^{64}_{29}Cu$

7. For the following parent nuclei undergoing β^+ decay, determine the daughter nucleus.
   a) $^{19}_{10}Ne$ b) $^{22}_{11}Na$ c) $^{46}_{24}Cr$ d) $^{239}_{93}Np$ e) $^{64}_{29}Cu$

8. Identify the missing nuclide and the type of reaction.
   a) $^{210}_{82}Pb \rightarrow ? + {}^{210}_{83}Bi$
   b) $^{214}_{83}Bi \rightarrow {}^{210}_{81}Tl + ?$
   c) $^{133}_{55}Cs \rightarrow {}^{133}_{55}Cs + ?$
   d) $^{230}_{90}Th \rightarrow {}^{226}_{88}Ra + ?$
   e) $^{240}_{94}Pu \rightarrow {}^{240}_{93}Np + ?$
   f) $^{35}_{17}Cl \rightarrow ? + {}^{35}_{18}Ar$

1a	$^{4}_{2}He$	1h	$^{0}_{1}e$	2e	alpha	3f	β^+	5b	$^{244}_{94}Pu$	6d	$^{45}_{21}Sc$	8a	$^{0}_{-1}e$, β^-
1b	$^{0}_{1}e$	1i	$^{0}_{1}e$	2f	positron	4a	$^{14}_{7}N$	5c	$^{219}_{84}Po$	6e	$^{64}_{30}Zn$	8b	$^{4}_{2}He$, α
1c	$^{0}_{-1}e$	1j	$^{0}_{0}\gamma$	3a	α	4b	$^{1}_{0}n$	5d	$^{240}_{92}U$	7a	$^{19}_{9}F$	8c	$^{0}_{0}\gamma$, γ
1d	$^{0}_{-1}e$	2a	positron	3b	β^-	4c	$^{4}_{2}He$	5e	$^{60}_{27}Co$	7b	$^{22}_{10}Ne$	8d	$^{4}_{2}He$, α
1e	$^{4}_{2}He$	2b	alpha	3c	β^-	4d	$^{0}_{1}e$	6a	$^{32}_{16}S$	7c	$^{36}_{23}V$	8e	$^{0}_{1}e$, β^+
1f	$^{0}_{-1}e$	2c	electron	3d	$^{0}_{0}\gamma$	4e	$^{20}_{10}Ne$	6b	$^{23}_{11}Na$	7d	$^{239}_{92}U$	8f	$^{0}_{-1}e$, β^-
1g	$^{0}_{0}\gamma$	2d	electron	3e	$^{0}_{0}\gamma$	5a	$^{234}_{90}Th$	6c	$^{35}_{17}Cl$	7e	$^{64}_{28}Ni$		

Half-Life

1. What is half-life?

____

2. If we start with 400 atoms of a radioactive substance, how many would we have after:
   a. one half-life? __________ c. three half-lives? __________
   b. two half-lives?__________ d. four half-lives? __________

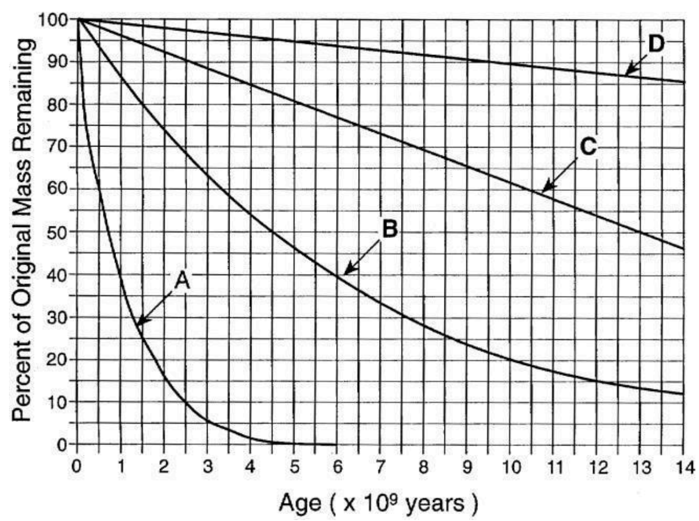
3. If we start with 48 atoms of a radioactive substance, how many would remain after:
   a. one half-life? __________ c. after three half-lives? ___________
   b. two half-lives? __________ d. after four half-lives? ___________

Using the graph to the right, answer the following questions.

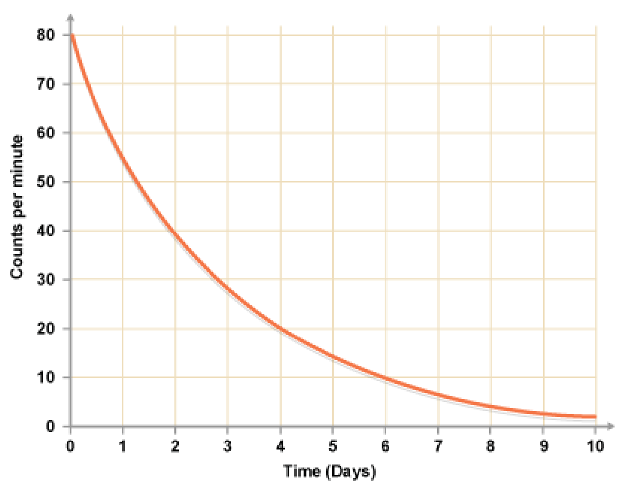
4. What is the half-life of A, B, and C?

5. Which element has the shortest half-life?

6. Which element is the most unstable?
   How do you know?



Use this graph to answer the following questions.



7. What is the original activity of the radioisotope? (measured in counts per minute)

8. How long is the half-life?

9. What is the activity after 2 half-lives?

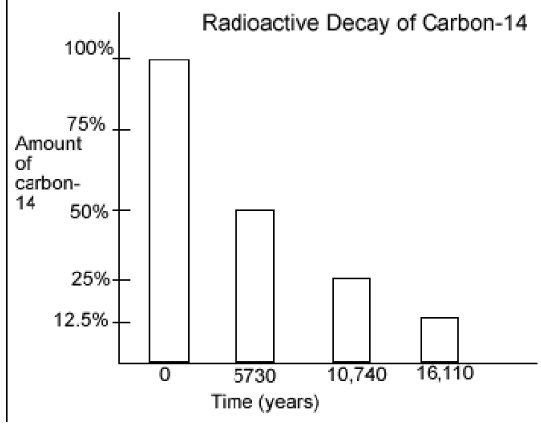
Use the graph on the right to answer the following questions.

10. How long is a half-life for carbon-14?

11. If only 25% of the carbon-14 remains, how old is the material containing the carbon-14?

12. If a sample originally had 120 atoms of carbon-14, how many atoms will remain after 16,110 years?

13. If a sample known to be about 10,740 years old has 400 carbon-14 atoms, how many atoms were in the sample when the organism died?



The table below shows the radioactive decay of a 600 g sample of Iodine-125.

Time (days)	Half-Lives	% of Parent Isotope Remaining	Fraction of Parent Isotope Remaining	Mass (g) of Parent Isotope	Mass (g) of Daughter Isotope
0	0	100%	1/1	600	0
60	1	50%	1/2	300	300
120	2	25%	1/4	150	450
180	3	12.5%	1/8	75	525
240	4	6.25%	1/16	37.5	562.5
300	5	3.125%	1/32	18.75	581.25
360	6	1.56%	1/64	9.4	590.6

14. What **percent** of iodine is left if 5 half-lives have passed?

15. What **percent** of iodine-125 has decayed if there are 37.5 grams of the original sample left?

16. What is the half-life of Iodine-125?

17. What **mass** of the Iodine-125 has decayed after 6 half-lives?

18. What **fraction** of the Iodine-125 remains after 300 days have passed?

19. How many half-lives would have to pass for there to be only 1.2 grams remaining?

20. How many grams of the daughter isotope are there after three half-lives?

1	notes	4a	0.75×10^9 a	11	10, 740 a	20	325 g
2a	200	4b	4.5×10^9 a	12	15 atoms		
2b	100	4c	13×10^9 a	13	1600 atoms		
2c	50	5	A	14	3.125%		
2d	25	6	A, shortest $t_{1/2}$	15	93.75%		
3a	24	7	80	16	60 days		
3b	12	8	2 days	17	590.6 g		
3c	6	9	20	18	1/32		
3d	3	10	5730 a	19	9 half lives		

Fission and Fusion

1. How much energy is released if 2.0 x 10^{-15} kg of material is converted directly into energy? (180 J)

2. What mass of Uranium must be converted into energy in order to release 27 000 MJ of energy? (3.0 x 10^{-7} kg)

3. A typical family car requires 1600 MJ of energy to travel from St. John's to Grand Falls. What mass of Uranium – 236 could power this car? (1.8 x 10^{-8} kg)

4. A nuclear decay of a single atom of Plutonium – 239 is shown below. The original mass of a Pu – 239 atom is 3.9695 x 10^{-25} kg, the mass of an alpha particle is 6.64424 x 10^{-27} kg, and the mass of Uranium – 235 is 3.902995 x 10^{-25} kg.

$$^{239}_{94}\mathrm{Pu} \xrightarrow[\text{years}]{24100} {}^{235}_{92}\mathrm{U} + {}^{4}_{2}\mathrm{He}$$

a) What is the initial mass of the reactant(s)? (3.9695 x 10^{-25} kg)
b) What is the final mass of the products? (3.96944 x 10^{-25} kg)
c) What is the mass difference for this reaction? (6.26 x 10^{-30} kg)
d) How much energy is released in one such decay? (5.634 x 10^{-13} J)

Use the table of masses given below to solve the problems which follow.

Nuclide	Mass (kg)	Nuclide	Mass (kg)
^{235}U	3.902995 x 10^{-25}	^{94}Sr	1.559501 x 10^{-25}
$^{4}_{2}He$	6.64424 x 10^{-27}	$^{1}_{0}n$	1.660540 x 10^{-27}
^{139}Xe	2.306800 x10^{-25}	^{1}H	1.673724 x 10^{-27}
^{2}H	3.344494 x 10^{-27}	^{3}H	5.008267 x 10^{-27}
$^{0}_{1}\beta$ or $^{0}_{-1}\beta$	9.109384 × 10^{-31}	$^{3}_{2}He$	5.008234 x 10^{-27}

5. Determine the energy liberated in a single reaction of the following:

a) $2\ {}^{1}_{1}H \rightarrow {}^{2}_{1}H + {}^{0}_{1}\beta$ (1.83876 x 10^{-13} J)

b) ${}^{1}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{2}He$ (8.98560 x 10^{-13} J)

c) $2\ {}^{3}_{2}He \rightarrow {}^{4}_{2}He + 2\ {}^{1}_{1}H$ (2.23020 x 10^{-12} J)

d) ${}^{235}U + {}^{1}n \rightarrow {}^{139}Xe + {}^{94}Sr + 2\ {}^{1}n$ (1.80797 x 10^{-10} J)

e) ${}^{2}H + {}^{2}H \rightarrow {}^{3}He + {}^{1}n$ (1.81926 x 10^{-12} J)