Physics 11
Energy Unit Test Solutions

	a.	b.	c.	d.
1.		X		
2.	X			
3.		X		X
4.				X
5.	X			X
6.	X			
7.		X		
8.				X
9.	X			
10.				X
11.			X	
12.			X	
13.			X	
14.	X			
15.	X			
16.				X
17.	X			
18.	X			
19.	X			
20.				X

1. **Problem**
   An object of mass 43.0 kg is moving with speed 2.00 m/s. What is its kinetic energy?
   a. $109\,\mathrm{J}$
   b. $86\,\mathrm{J}$
   c. $95.3\,\mathrm{J}$
   d. $128\,\mathrm{J}$

   Solution
   The kinetic energy is
   $$E_k = \frac{1}{2}mv^2 = \frac{1}{2}(43\,\mathrm{kg})(2\,\mathrm{m/s})^2 = 86\,\mathrm{J}$$

2. **Problem**
   An object of mass 75.0 kg is 2.00 m above the ground. What is its gravitational potential energy relative to the ground?
   a. $1470\,\mathrm{J}$
   b. $2190\,\mathrm{J}$
   c. $790\,\mathrm{J}$
   d. $1760\,\mathrm{J}$

   Solution
   The gravitational potential energy is
   $$E_p = mgh = (75\,\mathrm{kg})(9.80\,\mathrm{m/s^2})(2\,\mathrm{m}) = 1470\,\mathrm{J}$$

3. **Problem**
   Which of the following are units of energy? *Select all that apply.*
   a. $\mathrm{kg\,m\,s}$
   b. $\mathrm{kg\,m^2\,s^{-2}}$
   c. $\mathrm{kg\,m^2\,s^2}$
   d. $\mathrm{N\,m}$

   Solution
   The SI unit of energy is the joule (J). One joule is also equal to
   $$1\,\mathrm{J} = 1\,\mathrm{N\,m} = 1\,\mathrm{kg\,m^2\,s^{-2}}$$

4. **Problem**
   Albert pushes against a brick wall for 10 seconds. Mary pushes against the same wall for 20 seconds. The wall does not move. Compare the work done by each person.
   a. Mary does 2 times as much work as Albert.
   b. Mary does 10 seconds more work than Albert.
   c. The work done by each person depends on the force they applied.
   d. Both Albert and Mary do no work.

   Solution
   Work is force times distance ($W = Fd$). Since the wall does not move ($d = 0$), they both do no work.

5. **Problem**
   A cyclist going down a hill wants to shift gears to decrease his bicycle's mechanical advantage. This would make it so that he can exert a greater effort force on the bike. Which sprocket changes would result in a smaller mechanical advantage? *Select all that apply.*

   a. increase front sprocket radius.
   b. increase rear sprocket radius.
   c. decrease front sprocket radius.
   d. decrease rear sprocket radius.

   Solution
   The ideal mechanical advantage of a bicycle is

$$IMA = \frac{\text{rear sprocket radius}}{\text{front sprocket radius}} \cdot \frac{\text{pedal radius}}{\text{wheel radius}}$$

   To decrease the ideal mechanical advantage (which would also decrease the mechanical advantage if the efficiency does not change significantly), we can decrease the rear sprocket radius or increase the front sprocket radius.

6. **Problem**
   A pulley system lifts a 1632-N weight a distance of 3.5 m. Paul pulls the rope a distance of 19.8 m, exerting a force of 521 N. What is the efficiency of the system?

   a. 55.4 %
   b. 72.5 %
   c. 89.3 %
   d. 19.9 %

   Solution
   The formula for efficiency is

$$\text{efficiency} = \frac{MA}{IMA} = \frac{F_r/F_e}{d_e/d_r} = \frac{1632/521}{19.8/3.5} = 55.4\%$$

7. **Problem**
   An elevator is moving upwards at a constant speed of 3.53 m/s. The total mass of the elevator and passengers is 1230 kg. How much power is developed by the elevator's motor?

   a. $34\,\text{kW}$
   b. $42.6\,\text{kW}$
   c. $63.2\,\text{kW}$
   d. $24.1\,\text{kW}$

   Solution
   Power is force time velocity:

$$P = Fv = mgv = (1230.0\,\text{kg})(9.80\,\text{N/kg})(3.5\,\text{m/s}) = 42.6\,\text{kW}$$

8. **Problem**
   A box is pushed up an inclined plane. The angle of incline is 76° from the ground. What is the ideal mechanical advantage of the inclined plane?

   a. 1.540
   b. 1.300
   c. 1.410
   d. 1.030

   Solution
   The ideal mechanical advantage is the effort distance over the resistance distance. The effort distance is the along the inclined surface, which is the hypotenuse of the right triangle. The resistance distance is the vertical distance, which is the side opposite the angle.

$$IMA = \frac{d_e}{d_r} = \frac{\text{hypotenuse}}{\text{opposite}} = \frac{1}{\sin(76^\circ)} = 1.031$$

9. **Problem**
   How much power is required to lift a box that weighs $609\,\text{N}$ a distance of $6.0\,\text{m}$ straight up in $12.0\,\text{s}$?

   a. $304\,\text{W}$
   b. $373\,\text{W}$
   c. $432\,\text{W}$
   d. $271\,\text{W}$

   Solution
   Power is work over time:

$$P = \frac{W}{t} = \frac{Fd}{t} = \frac{(609\,\text{N})(6.0\,\text{m})}{12.0\,\text{s}} = 304\,\text{W}$$

10. **Problem**
    How much work is done (by you) if you raise a 3.0 N weight 6.0 m above the ground?

    a. 9.5 J
    b. 176.4 J
    c. 55.1 J
    d. 18.0 J

    Solution
    Work is force times distance.

$$W = Fd = (3.0\text{ N})(6.0\text{ m}) = 18.0\text{ J}$$

11. **Problem**
A rope is used to pull a box $17.0\,\text{m}$ across the floor. The rope is held at an angle of $35.0°$ with the floor and a force of $128\,\text{N}$ is used. The mass of the box is $54\,\text{kg}$ and the coefficient of kinetic friction between the box and the ground is 0.24. How much work does the force on the rope do?

    a. $1050\,\text{J}$
    b. $2180\,\text{J}$
    c. $1780\,\text{J}$
    d. $1230\,\text{J}$

    Solution
    Work is the component of force in the direction of motion times the distance. The coefficient of kinetic friction and the mass of the box are not needed because the question asks for the work done by the force on the rope and not the work done by friction.

$$W = Fd\cos\theta = (128\,\text{N})(17.0\,\text{m})\cos(35.0°) = 1780\,\text{J}$$

12. **Problem**
How much work does the force of gravity do when a 60.0-N object falls a distance of 18.6 m?

    a. 0 J
    b. 10900 J
    c. 1120 J
    d. 10600 J

    Solution
    Work is force times distance.

$$W = Fd = (60.0\text{ N})(18.6\text{ m}) = 1120\text{ J}$$

13. **Problem**
A simple machine with mechanical advantage greater than 1

    a. increases friction.
    b. increases energy.
    c. increases effort force.
    d. decreases effort force.

    Solution
    The mechanical advantage, MA, of a simple machine is

$$MA = \frac{F_r}{F_e}$$

If this ratio is greater than 1, then $F_r > F_e$. This means that the simple machine increases the effort force.

14. **Problem**
A ball drops some distance and gains 74 J of kinetic energy. Do **NOT** ignore air resistance. How much gravitational potential energy did the ball lose?

    a. More than 74 J.
    b. Exactly 74 J.
    c. Less than 74 J.
    d. Cannot be determined.

    Solution
    Some of the potential energy was transformed into kinetic energy and some into non-mechanical energy (heat, sound, vibrations, etc.) because of the air resistance. Therefore, the potential energy lost is more than the kinetic energy gained.

15. **Problem**
The transfer of energy by mechanical means is

    a. work
    b. momentum
    c. acceleration
    d. force

    Solution
    The transfer of energy by mechanical means (applying a force over a distance) is work.

16. **Problem**
A 1883-kg car is traveling at 19 m/s. The brakes are suddenly applied and the car slides to a stop. The average braking force between the tires and the road is 9169 N. How far will the car slide once the brakes are applied?

    a. 50.9 m
    b. 45.9 m
    c. 55.1 m
    d. 37.1 m

    Solution
    The work done by the brakes equals the kinetic energy of the car.

$$W = Fd = \frac{1}{2}mv^2$$

Therefore, solving for d,

$$d = \frac{m}{2Fv^2} = 37.1\,\mathrm{m}$$

17. **Problem**
A car moving at 62 km/h comes to a stop in 66 m after the driver applies the brakes. How far would the same car take to stop if it were moving at 37 km/h? Assume identical road conditions and braking force.

   a. $23.5\,\mathrm{m}$
   b. $31.5\,\mathrm{m}$
   c. $34.2\,\mathrm{m}$
   d. $26.1\,\mathrm{m}$

Solution
The braking force does work to remove the kinetic energy of the car. Since kinetic energy depends on velocity squared, the car has $(37/62)^2 = 0.3561394$ times the kinetic energy when it is traveling at 37 km/h than when it is traveling at 62 km/h. The work done by the brakes must also be multiplied by $(37/62)^2$.

Since $W = Fd$ and we are assuming the same braking force, the distance must be multiplied by $(37/62)^2$.

$$d = (37/62)^2(66\,\mathrm{m}) = 23.5\,\mathrm{m}$$

18. **Problem**
The net work done on an object is equal to its

   a. change in kinetic energy.
   b. change in potential energy.
   c. change in velocity.
   d. change in total mechanical energy.

Solution
According to the work-energy theorem, the net work done on an object is equal to its change in kinetic energy. Note that the net work could include *negative* work done by gravity or friction so that an applied force could do work on an object without increasing its kinetic energy.

19. **Problem**
A test rocket of mass 58 kg is fired straight up. Its fuel gives it a kinetic energy of 9292 J by the time the rocket engine burns all the fuel. What additional height will the rocket rise?

   a. $16.3\,\mathrm{m}$
   b. $24.2\,\mathrm{m}$
   c. $20.1\,\mathrm{m}$
   d. $10.8\,\mathrm{m}$

Solution
The rocket will rise an additional height such that all of its kinetic energy is transformed into gravitational potential energy, $E_p = mgh$.

$$h = \frac{E_p}{mg} = \frac{(9292\,\mathrm{J})}{(58\,\mathrm{kg})(9.80\,\mathrm{m/s^2})} = 16.3\,\mathrm{m}$$

20. **Problem**
    Ollie's mass is 15.0 kg. He climbs the 6.4-m ladder of a slide, and reaches a velocity of 5.5 m/s at the bottom. How much work was done by friction on Ollie?

    a. 956 J
    b. 554 J
    c. 364 J
    d. 714 J

    Solution
    The work done by friction is the difference between the initial potential energy and the final kinetic energy.

$$W = mgh - \frac{1}{2}mv^2 = m(gh - \frac{1}{2}v^2)$$

$$W = (15\,\mathrm{kg})[(9.80\,\mathrm{m/s^2})(6.4\,\mathrm{m}) - \frac{1}{2}(5.5\mathrm{m/s})^2] = 714\,\mathrm{J}$$