

Physics 11

Energy Unit Test Solutions

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

1. Problem

An object of mass 20.0 kg is moving with speed 7.00 m/s. What is its kinetic energy?

- a. 541 J
- b. 733 J
- c. 605 J
- d. 490 J

Solution

The kinetic energy is

$$E_k = \frac{1}{2}mv^2 = \frac{1}{2}(20\text{ kg})(7\text{ m/s})^2 = 490\text{ J}$$

2. Problem

An object of mass 49.0 kg is 10.00 m above the ground. What is its gravitational potential energy relative to the ground?

- a. 4800 J
- b. 3120 J
- c. 3650 J
- d. 2450 J

Solution

The gravitational potential energy is

$$E_p = mgh = (49\text{ kg})(9.80\text{ m/s}^2)(10\text{ m}) = 4800\text{ J}$$

3. Problem

Which of the following are units of energy? *Select all that apply.*

- a. N m
- b. J
- c. kg m s^{-2}
- d. kg m s

Solution

The SI unit of energy is the joule (J). One joule is also equal to

$$1\text{ J} = 1\text{ N m} = 1\text{ kg m}^2\text{ s}^{-2}$$

4. Problem

The transfer of energy by mechanical means is

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

Solution

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

5. Problem

A cyclist climbing up a hill wants to shift gears to increase his bicycle's mechanical advantage. This would make it so that a smaller effort force is needed to overcome the force of gravity on the bike. Which sprocket changes would result in a greater 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 increase the ideal mechanical advantage (which would also increase the mechanical advantage if the efficiency does not change significantly), we can increase the rear sprocket radius or decrease the front sprocket radius.

6. Problem

A pulley system lifts a 1939-N weight a distance of 0.733 m. Paul pulls the rope a distance of 9.59 m, exerting a force of 165 N. What is the efficiency of the system?

- a. 89.8 %
- b. 67.4 %
- c. 86.6 %
- d. 65.7 %

Solution

The formula for efficiency is

$$\text{efficiency} = \frac{MA}{IMA} = \frac{F_r/F_e}{d_e/d_r} = \frac{1939/165}{9.6/0.733} = 89.8\%$$

7. Problem

An elevator is moving upwards at a constant speed of 3.5 m/s. The total mass of the elevator and passengers is 1581 kg. How much power is developed by the elevator's motor?

- a. 54.2 kW
- b. 80.8 kW
- c. 74.6 kW
- d. 68.3 kW

Solution

Power is force time velocity:

$$P = Fv = mgv = (1581.0 \text{ kg})(9.80 \text{ N/kg})(3.5 \text{ m/s}) = 54.2 \text{ kW}$$

8. Problem

A box is pushed up an inclined plane. The angle of incline is 37° from the ground. What is the ideal mechanical advantage of the inclined plane?

- a. 1.660
- b. 1.270
- c. 1.470
- d. 0.880

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.

$$IMA = \frac{d_e}{d_r} = \frac{\text{hypotenuse}}{\text{opposite}} = \frac{1}{\sin(37^\circ)} = 1.662$$

9. Problem

How much power is required to lift a box of mass 38 kg a distance of 13.0 m straight up in 29.0 s?

- a. 227 W
- b. 191 W
- c. 88.7 W
- d. 167 W

Solution

Power is work over time:

$$P = \frac{W}{t} = \frac{Fd}{t} = \frac{mgh}{t} = \frac{(38 \text{ kg})(9.80 \text{ N/kg})(13.0 \text{ m})}{29.0 \text{ s}} = 167 \text{ W}$$

10. Problem

How much work is done (by you) if you raise a 1.0 N weight 5.0 m above the ground?

- a. 0.0 J
- b. 49.0 J
- c. 5.0 J
- d. 21.4 J

Solution

Work is force times distance.

$$W = Fd = (1.0 \text{ N})(5.0 \text{ m}) = 5.0 \text{ J}$$

11. Problem

A rope is used to pull a box 11.0 m across the floor. The rope is held at an angle of 28.0° with the floor and a force of 355 N is used. The mass of the box is 70 kg and the coefficient of kinetic friction between the box and the ground is 0.34. How much work does the force on the rope do?

- a. 3900 J
- b. 3450 J
- c. 1820 J
- d. 2790 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.

$$W = Fd \cos \theta = (355 \text{ N})(11.0 \text{ m}) \cos(28.0^\circ) = 3450 \text{ J}$$

12. Problem

How much work does the force of gravity do when a 25.0-N object falls a distance of 15 m?

- a. 3680 J
- b. 899 J
- c. 115 J
- d. 375 J

Solution

Work is force times distance.

$$W = Fd = (25.0 \text{ N})(15.0 \text{ m}) = 375 \text{ J}$$

13. Problem

A simple machine with mechanical advantage less 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 less than 1, then $F_r < F_e$. This means that the simple machine decreases the effort force.

14. Problem

A ball drops some distance and gains 16 J of kinetic energy. Do **NOT** ignore air resistance. How much gravitational potential energy did the ball lose?

- a. More than 16 J.
- b. Exactly 16 J.
- c. Less than 16 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

A 1911-kg car is traveling at 14 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 5453 N. How far will the car slide once the brakes are applied?

- a. 50.3 m
- b. 17.2 m
- c. 34.3 m
- d. 30.0 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 ,

$$d = \frac{m}{2Fv^2} = 34.3 \text{ m}$$

16. Problem

A car moving at 47 km/h comes to a stop in 67 m after the driver applies the brakes. How far would the same car take to stop if it were moving at 100 km/h? Assume identical road conditions and braking force.

- a. 152.8 m
- b. 271.8 m
- c. 303.3 m
- d. 197.9 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 $(100/47)^2 = 4.5269353$ times the kinetic energy when it is traveling at 100 km/h than when it is traveling at 47 km/h. The work done by the brakes must also be multiplied by $(100/47)^2$.

Since $W = Fd$ and we are assuming the same braking force, the distance must be multiplied by $(100/47)^2$.

$$d = (100/47)^2(67 \text{ m}) = 303.3 \text{ m}$$

17. Problem

The net work done on an object is equal to its

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

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.

18. Problem

An electric motor develops 12.0 kW of power as it lifts a loaded elevator up a distance of 26.0 m. The total mass of the elevator and passengers is 3175 kg. How long does the elevator take to complete complete this trip?

- a. 76.5 s
- b. 47.5 s
- c. 67.4 s
- d. 91.8 s

Solution

Power is work over time, so time is work over power:

$$t = \frac{W}{P} = \frac{Fd}{P} = \frac{mgh}{P} = \frac{(3175.0 \text{ kg})(9.80 \text{ N/kg})(26.0 \text{ m})}{12000 \text{ W}} = 67.4 \text{ s}$$

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. 10.2 m
- b. 16.3 m
- c. 8.3 m
- d. 12.5 m

Solution

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

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

20. Problem

Yuki's mass is 62.0 kg. He climbs the 4.5-m ladder of a slide, and reaches a velocity of 3.4 m/s at the bottom. How much work was done by friction on Yuki?

- a. 3560 J
- b. 3280 J
- c. 2380 J
- d. 2690 J

Solution

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

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

$$W = (62 \text{ kg})[(9.80 \text{ m/s}^2)(4.5 \text{ m}) - \frac{1}{2}(3.4 \text{ m/s})^2] = 2380 \text{ J}$$