Outcomes on Energy
Describe the relationship between work and energy.
Calculate work done by a force.
Identify the force that does work.
Differentiate between work and power and correctly calculate power used.
Calculate the kinetic energy of a moving object.
Calculate the gravitational potential energy of a system.
Identify ways in which elastic potential energy is stored in a system.
Solve problems using the law of conservation of energy.
Understand and use the work-change in energy theorem.

PART I: TRUE OR REWRITE

For each of the statements below, write true or rewrite the italicized part to make the statement true.

1. When you throw a ball into the air its total mechanical energy at any point is the difference in its kinetic energy and gravitational potential energy.
   false, sum

2. As an object falls towards Earth, the gravitational potential energy of the object increases.
   false, increases

3. The total amount of energy in an isolated, closed system remains constant.
   true

4. If a tabletop is used as reference point in a mechanical-energy problem, an object lying on the tabletop has a gravitational potential energy greater than zero.
   false, equal to

5. Of the three sets of bar graphs below, an inelastic collision is represented by set A.
   false, set B
PART II: MATCHING
For each term on the left, write the letter of the matching item.

____ C 6. KE  a. KE_{after} + PE_{after} = KE_{before} + PE_{before}
____ B 7. PE  b. = mgh
____ D 8. 1 joule  c. = 1/2 mv^2
____ A 9. Law of Conservation of Energy  d. = 1 kg*m^2/s^2
____ E 10. result of an elastic collision  e. Fd = ΔKE

PART III: VOCABULARY – Put the number of the term on the line which matches the question.
a. work  b. power  c. Joule  d) potential energy
e. Watts  f. 1000  g. 100  h. 10
i. zero  j. distance  k. energy

11. The force of one Newton acting through a distance of one meter produces one ______ of work.
12. The energy stored in an object because of its position is called ________.
13. The ability to change an object or its environment is called ________.
14. The rate at which energy is transferred or the rate of doing work is ________.
15. ________ is the unit of energy.
16. The unit of power is ________.
17. The number of Watts in a kilowatt is ________.
18. The unit of work is ________.

PART IV: APPLYING CONCEPTS
19. Two students move 80.0 N cartons of books from the floor onto a cart. Student one moves 12 cartons in 7 minutes. Student Two moves 12 cartons in 5 minutes. Which student does more work?

SAME WORK, DIFFERENT POWERS

PART V: PROBLEMS
Use this problem for 20-22. An 800.0 N force pushes a 150. kg mass 10.0 meters horizontally across the floor. Calculate the work done.

20. What are the units of your final answer?
   a) Newtons  b) Joules  c) Watts  d) meters  e) kilowatts.

21. There is too much information in this problem. What is the piece of information that will not be used to calculate the answer?
   a) 800.0 N  b) 150. Kg  c) 10.0 m  d) horizontally  e) all the data is needed to answer.

22. What is the work done?
   a) \(1.5 \times 10^3\) W  b) 1500 W  c) 8000. J  d) \(8.00 \times 10^3\) J  e) \(1.20 \times 10^5\) J
Use this problem for 23-25. The work done to lift 50.0 kilograms of physics books from the floor to a shelf above the floor is 125.0 J.

23. How is the weight of the books calculated?
   a) mass x gravity   b) mass/gravity   c) work/time   d) energy/mass

24. What is the weight of the books?
   a) 490. N   b) 5.10 N   c) 62.5 N   d) 2.50 N

25. What is the height of the shelf?
   a) 2.55 meters   b) .255 meters   c) 2.50 meters   d) 6,250 meters

Use this problem for 26-28. A student whose mass is 75 kg walks up the stairs which are 3.5 meters high. She does this in 6.5 seconds. What is the power output?

26. What is the student’s weight?
   a) 740 N   b) 7.7 N   c) 40. N   d) 460 N

27. What are the units for the final power output?
   a) Newtons   b) Joules   c) Watts   d) meters

28. What is the magnitude of the power?
   a) 40   b) 4.0 x 10^1   c) 390   d) 4.0 x 10^2

Use this problem for 29-30. It took a force of 250 N to pull a crate of toys across the floor. The work done was 3500 Joules. How far was the crate moved?

29. The units for the final answer are
   a) Newtons   b) Joules   c) Watts   d) meters

30. What is the magnitude of the final answer?
   a) 875000   b) 89000   c) 14   d) 14,000

Use this problem for 31-32. A 50.0 g bullet travels at a speed of 750.0 m/s.

31. What is its kinetic energy?
   a) 38 J   b) 37.5 J   c) 14062 J   d) 1.40 x 10^4 J   e) The bullet has no kinetic energy

32. When the bullet falls to the earth and comes to a stop, what is its potential energy?
   a) The same as its maximum kinetic energy, it has all turned into potential energy
   b) Unknowable from this information
   c) 0

Use this problem for 33-34. A 20. kg mass is on the edge of a 29 m high cliff.

33. What potential energy does it possess?
   a) 5700 J   b) 5600 J   c) 580 J   d) 600 J   e) 0
34. The mass now falls from the cliff; what is the maximum kinetic energy it can gain from gravity in this fall?
   a) None. Energy can’t come from an acceleration, such as gravity.
   b) There is definitely energy, but it is unknowable with the current information
   c) 5700 J

35. What is the x component of the pushing force?
   a) 57.7 N  b) 57.7 J  c) 6.4 N  d) 6.4 J  e) 88.0 N

36. How much work is being applied to the mower over this distance?
   a) 80 J  b) 8.0 \times 10^3 J  c) 8.0 \times 10^4 J  d) 8.0 \times 10^5 J  e) 80 J

37. **Extra Hard: Also not on the test.** At what rate (speed) can a 150 W motor lift a 2500 N load? Hint: Think carefully about units.
   a) .06 m/s  b) 17 m/s  c) 3.8 \times 10^5 m/s  d) 260 m/s  e) 6.0 m/s

Matching: Write the letter that correctly completes the statement. The term can be used more than once or not at all.

38. C
   A ________ is a unit of power defined as 1 Joule per second.
   A) Kinetic Energy  B) Second  C) Potential Energy

39. A
   The type of energy that is caused by an object’s position above the ground is the object’s ________.
   D) Power

40. A
   The energy that results from the motion of an object is called ________.
   E) Energy

41. I
   The rate of doing work is called ________.
   F) Mechanical Energy

42. H
   The ________ is the SI unit used for work.
   G) Watt

43. I
   When an applied force is multiplied by the distance through which the force is applied, ________ is calculated.
   J) Joule

44. G
   A ________ is a unit of force defined as 1 kg m/s².
   I) Newton

45. F
   This is the sum of potential and kinetic energy.
   K) Work

Multiple Choice. Write the letter of the choice that best completes the statement or answers the question.

46. Any object that has energy has the ability to ________.
   A. produce a change  B. fall  C. burn
47. When a force is exerted on an object, work is done only if the object ________.
   A. moves    B. remains stationary    C. is heavy    D. has no momentum

48. In which of the following situation is no work done on a football?
   A. dropping the football
   B. picking up the football
   C. carrying the football down the field

49. In which of the following situation is that work done on the football by gravity?
   A. dropping the football
   B. picking up the football
   C. carrying the football down the field

50. Jimmy gets on the escalator at Macy’s department store. The length of the escalator is 14.0 meters and is at a 30.0° inclination with the ground floor. (Think about the direction of force and the direction of the displacement). If Jimmy has a mass of 42.0 kg, how much work does the escalator do on Jimmy to lift him to the second floor?

   \[
   \begin{align*}
   F_y &= 411.6 \text{ N} \left( \cos 30° \right) \\
   F_x &= 205.8 \text{ N} \\
   W &= 205.8 \text{ N} \cdot 14 \text{ m} \cdot \cos 30° \\
   W &= 2881.2 \text{ J}
   \end{align*}
   \]

   \[
   \begin{align*}
   W &= \Delta PE \\
   W &= mgh \\
   W &= (42.0 \text{ kg})(9.80 \text{ m/s}^2)(7 \text{ m}) \\
   W &= 2881.2 \text{ J}
   \end{align*}
   \]

51. A pulley system consists of two fixed pulleys and two movable pulleys that lift a load that has a weight of 300 N. If the effort force used to lift the load is 100 N, what is the mechanical advantage of the system?
   a. 1/3    b. 3/4    c. 3    d. 6
   \[\text{NOT ON TEST}\]

52. A box in the diagram is being pushed up the ramp with a force of 100.0 N. If the height of the ramp is 3.0 m, what is the work done on the box? The angle with the horizontal is 30 degrees.

   \[
   F_d = APE \\
   F_d = 5 \sin 30° = 3 \text{ m}
   \]

   \[
   W = F_d \cdot \cos \theta \\
   W = (100.0 \text{ N})(6.0 \text{ m})(\cos 0°) \\
   W = 600 \text{ J}
   \]

53. A skater with a mass of 50.0 kg slides across an icy pond with negligible friction. As he approaches a friend, both he and his friend hold out their hands, and the friend exerts a force in the direction opposite to the skater’s movement, which slows the skater’s speed from 2.0 m/s to 1.0 m/s. What is the change in the skater’s kinetic energy?
   a. 25 J    b. 75 J    c. 100 J    d. 150 J

   \[
   \Delta KE = \frac{1}{2}mv^2 - \frac{1}{2}mv^2 \\
   \Delta KE = \frac{1}{2}(50.0 \text{ kg})(1.0 \text{ m/s})^2 - \frac{1}{2}(50.0 \text{ kg})(2.0 \text{ m/s})^2 \\
   25 \text{ J} - 100 \text{ J} = -75 \text{ J}
   \]
PE before + KE before = PE after + KE after

PE = mgh  KE = \frac{1}{2} mv^2  g = 9.81 \text{ m/s}^2

54. A 100 kg roller coaster comes over the first hill at 2 m/sec (v_0). The height of the first hill (h) is 20 meters. See roller diagram below.

\[ KE = \frac{100 \text{ kg} \cdot (2 \text{ m/s})^2}{2} = \frac{200 \text{ J}}{2} = 100 \text{ J} \]

\[ V = 2 \text{ m/s} \]

\[ PE = mgh = (100 \text{ kg} \cdot 9.81 \text{ m/s}^2 \cdot 20 \text{ m}) = 19,600 \text{ J} \]

\( w. \)

a) Find the total energy for the roller coaster at the initial point.

\[ KE = 200 \text{ J} \]
\[ PE = 19,600 \text{ J} \]
\[ TME = 200 \text{ J} + 19,600 \text{ J} = 21,600 \text{ J} \]

b) Find the potential energy at point A using the PE formula.

\[ PE \text{ at point A is the same as initial point} \]
\[ PE = 19,600 \text{ J} \]

c) Use the conservation of energy to find the kinetic energy (KE) at point B.

\[ TME = PE + KE \]
\[ 21,600 \text{ J} = \frac{1}{2}(19,600) + KE \]
\[ 21,600 \text{ J} = 9,800 + KE \]
\[ KE = 11,800 \text{ J} \]

d) Find the potential energy at point C.

\[ PE = 0 \]

e) Use the conservation of energy to find the Kinetic Energy (KE) of the roller coaster at point C.

\[ TME = KE + PE \]
\[ 21,600 \text{ J} = KE + 0 \text{ J} \]
\[ KE = 21,600 \text{ J} \]

f) Use the Kinetic Energy from C, find velocity of the roller coaster at point C.

\[ KE = \frac{1}{2} mv^2 \]
\[ 21,600 \text{ J} = \frac{1}{2} (100 \text{ kg}) V^2 \]
\[ 432 \text{ m}^2 \text{s}^{-2} = V^2 \]
\[ 20.8 \text{ m/s} = V \]