1. In the context of physics, **work** is
   A) a vector quantity representing an object's state of motion.
   B) a scalar quantity representing the process by which an object's state of motion can be changed.
   C) a constant quantity representing the mass of an object.
   D) that thing you do every day to earn a paycheck.

2. In order for a force to do work on an object, the force and the displacement of the object must be
   A) parallel. C) vertical.
   B) perpendicular. D) horizontal.

3. A tugboat pulls on a tanker using a constant force $F = 5.4\times10^6$N. It tows the tanker through a distance of 1.5 miles ($d = 2.4\times10^3$m). How much work was done on the tanker by the tugboat?
   A) None; $W = 0$ J. D) $W = 2.0\times10^{12}$ J
   B) $W = 7.8\times10^9$ J E) $W = 3.9\times10^{12}$ J
   C) $W = 1.3\times10^{10}$ J F) Not enough information!

4. A girl pulls her baby brother in a wagon. She applies a horizontal force of 90 lb (**400 N**) to pull the 50 lb (**220N**) loaded wagon a distance of 100ft (**30m**) down the sidewalk. How much work has the girl done?
   A) 4,000J C) 5,400 J E) 9,000 J
   B) 5,000 J D) 6,600 J **F) 12,000 J**

5. How much work has been done by the force of **gravity** on the wagon?
   A) $W = (220\text{ N}) \times (30\text{ m}) = 6{,}600$ J
   B) $W = (400\text{ N}) \times (30\text{ m}) = 12{,}000$ J
   C) $W = (220\text{ N} + 400\text{ N}) \cdot (30\text{ m}) = 18{,}600$ J
   D) Zero! Gravity is perpendicular to the motion!

6. An object is in motion when a force is applied to it. The force does **negative work** on the object. What does this mean? Doing negative work on an object
   A) will slow it down.
   B) will speed it up.
   C) will cause no change to its motion.
   D) will change its direction of motion (i.e., from +x to –y).

7. A hockey puck slides across the ice. Friction exerts a force $F = -0.150$N as the puck slides $d = 25$m (about the length of a hockey rink). How much **work** was done by **friction**?
   A) –0.006 J **C) –3.75 J** E) –167 J
   B) +0.006 J D) +3.75 J F) +167 J

8. How much **power** is developed when the **70 kg** Lone Centurion (Rory) runs up a **4 m** staircase in a time of **5 seconds**?
   A) 0 W C) 87.5 W **E) 549 W**
   B) 56 W D) 280 W F) 875 W

9. At 58kg, Amy is **less massive** than Rory. In order to develop exactly the **same amount of power** running the same 4 m stairs, she must do it in
   A) more time.
   B) less time.
   C) exactly the same amount of time.
   D) Trick question! Less mass, less power. Always.

10. The Dodge Challenger Hellcat can develop 707 horsepower. What does this mean? What is horsepower?
    A) The unit is figurative; when cars began to replace horses in the early 1900s, people used to joke about a car taking the place of 2 horses.
    B) The unit is literal, and based on actual estimates of how much work a typical horse could do: lifting a 220lb load through 100 feet per minute over a 4 hour shift.

11. In the context of physics, **energy** is
    A) a process: an object can do/perform energy.
    B) a property: an object can have/possess energy.
    C) a constant: all objects contain equal energy.
    D) a mystery. Physicists have no idea how energy works.

12. Which of the following is **not** a form of **potential energy**?
    A) Gravitational. D) Spring (or elastic).
    B) Electrical. **E) All of these are examples of potential energy!**
    C) Magnetic.

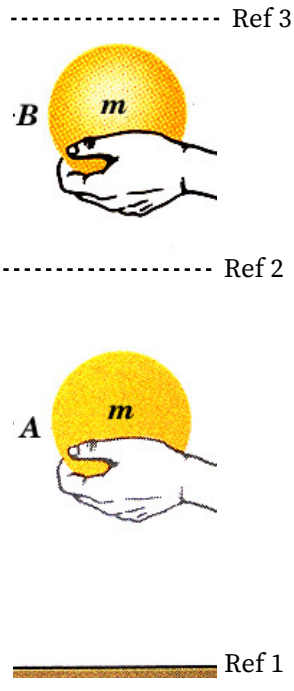
13. Which of the following is **not** an example of a form of potential energy?
    A) You nock an arrow and draw your bow. When you let go, elastic potential in the string will cause the arrow to fly forward at great speed.
    B) You place your iced tea too close to the edge of the table. As the glass falls to the deck, gravitational potential energy is converted to kinetic energy.
    C) You are jumping on a trampoline. As you come down, your kinetic energy is converted to elastic potential energy as the trampoline membrane stretches.
    D) You are toasting marshmallows, and yours got too close to the campfire! As the marshmallow burns, stored chemical potential is released in the form of heat.
    E) You paint the living room walls. As the paint dries, the kinetic energy of the paint molecules is converted to pigment potential. This is why paint always dries a slightly darker color.

14. **True** or false: An object at rest may possess potential energy.

15. **True** or false: An object may have either positive or negative potential energy.

16. A simple recurve bow has a 27lb draw, which means it requires 27lb of force to fully extend the bowstring. True or **false**: A partially drawn bowstring will have the same potential energy as a fully drawn string.

17. Two tennis balls are held above the ground as shown on the right. You want the calculate the potential energy of each, PE_A and PE_B. Where would you choose to set a **reference level** so that both values are **positive**?



    A) Ref 1: Use any reference level that is below both balls (like the tabletop, or the floor).
    B) **Ref 2**: Choose as a reference level any line in between the two balls.
    C) **Ref 3**: Any reference level located above both balls will make both values of PE positive.
    D) It does not matter where you set the reference level, PE_A will always be negative and PE_B will always be positive.

18. To say that **potential energy** is **relative** means that
    A) it cannot be measured. Any calculation of PE is just a guess, and may (or may not) be accurate in any way.
    B) it must always be calculated with respect to the ground (or the surface of whatever planet you happen to be standing on). It is meaningless and inaccurate to use any other reference for the calculation.
    C) you must always define a reference level, or a point (surface) at which $h = 0$, and the $PE = 0$. Depending on the situation you are analyzing, you might select a reference that is not the ground, but has meaning in the context of the problem.
    D) it was discovered by Einstein in 1905 when he was working on his calculations of special relativity.

19. How are potential and kinetic energy different?
    A) Kinetic energy comes in many forms, but potential energy only exists as one form of motion.
    B) Kinetic energy is energy of motion. Potential energy is heat.
    C) Kinetic energy is stored. Potential energy is energy of motion.
    D) Kinetic energy is stored heat, potential energy is transferred heat.
    E) Potential energy is stored energy. Kinetic energy is energy of motion.

20. You push a box of books across the floor. As you push the box forward, the force of friction
    A) also acts in the forward direction, doing positive work. This increases the KE of the box.
    B) acts in the forward direction, but does negative work. This decreases the PE of the box.
    C) acts in the backward direction, doing negative work. This decreases the KE of the box.
    D) acts in the backward direction, doing positive work. This increases the PE of the box.

21. To increase an object's kinetic energy,
    A) increase its potential energy. If PE increases, the KE automatically increases as well.
    B) a force must do negative work on the object. Friction is an example of a force which can do negative work.
    C) a force must do positive work. For example, when you push a grocery cart down the aisle, you are increasing the KE of the cart with positive work.
    D) either B or C; doing either positive or negative work will always increase an object's KE.
    E) change its potential energy, either up or down. The only way to change an object's KE is to change its PE.

22. **True** or false: Every moving object must possess kinetic energy.

23. True or **false**: A car traveling **north** has **+365kJ** of kinetic energy. The same car, traveling **south** at the same speed will have **–365kJ** of KE.

24. Calculate the kinetic energy of a 135 lb (m = 61 kg) skier moving at 18mph (v = 8.0 m/s). **Answer numerically** (enter the number only, and do not include any units).

25. **True** or false: The skier converts chemical energy (breakfast!) into mechanical energy (skiing!).

26. As the skier slaloms downhill, her speed increases. If the skier is **speeding up,**
    A) kinetic energy is being converted into gravitational potential energy.
    B) gravitational PE is being converted into KE.
    C) kinetic energy is increasing for some unknown reason. There is no exchange betweenKE and PE.

27. If the skier (m = 61kg) reaches the bottom of the hill with a speed v_i = 14 m/s, how much work must the force of friction do to bring her to rest (v_f = 0)?
    A) –427 J C) –854 J **E) –5978 J**
    B) +427 J D) +854 J F) +5978 J

28. You throw a tennis ball vertically, straight down towards the ground, with some initial velocity v_o. As the ball falls,
    A) its KE increases while its PE decreases.
    B) its KE decreases as its PE increases.
    C) KE and PE both remain constant.
    D) both KE and PE decrease.
    E) KE and PE both increase.

29. Kitten says he gets his energy from sleeping. Sasquatch says he gets his energy form eating. Who is right?
    A) Kitten! C) Both!
    B) Sasquatch! D) Neither!

30. How many forms of energy are there?
    A) Exactly zero. Energy does not exist.
    B) Exactly one: kinetic energy.
    C) Exactly two: energy may be kinetic or potential.
    D) Many. KE and PE are two examples, but there exist other forms of energy as well.

31. Which of the following is **not** a form of energy?
    A) Mechanical. D) Electrical.
    B) Chemical. **E) Psychic.**
    C) Radiant. F) Nuclear.

32. **True** or false: If you transform chemical energy (breakfast) into mechanical energy (walking across campus), you will also generate waste heat.

33. True or **false**: Some energy transformations are possible (like potential to kinetic), but other transformations are not possible (like mechanical to electrical).

34. In the context of physics, what do we mean by conservation of energy?
    A) Energy is continually created, but without careful conservation, it will be easily destroyed.
    B) Energy cannot be created, so unless it is carefully conserved, it will be destroyed, leaving nothing.
    C) Energy cannot be created or destroyed; it can only be transferred from one object to another, or transformed from one type of energy to another.
    D) Energy cannot be created or destroyed. It cannot be transferred from one object to another, and it definitely cannot change form (like from electrical to mechanical).

35. Which of the following is not allowed by the law of energy conservation?
    A) Energy can be exchanged one form for another; i.e., potential energy can become kinetic.
    B) Elastic potential energy can be changed into gravitational potential energy.
    C) Energy can be moved from one object to another as one object does work on the other.
    D) Energy can be created or destroyed; i.e., when a bowling ball rolls across a carpet and slows down, its kinetic energy is completely destroyed.
    E) All of the above are allowed and consistent with the law of energy conservation.

36. **True** or false: In 2013, the United States comprised 5% of the global population, yet consumed 18% of the world's energy.

37. When you examine the energy statistics for 2015, how is the bulk of the energy consumed in the US?
    A) The most energy is consumed by the Residential sector.
    B) Commercial energy use is greater than any other sector.
    C) The Industrial sector consumes the largest fraction.
    D) The Transportation sector edges out Industrial for greatest consumption.
    E) All four sectors (Residential, Commercial, Industrial, Transportation) use the same amount of energy.

38. Of the 97.5 Quads of energy consumed by the US in 2015, how much of that went to waste (Rejected Energy)?
    A) Very little: About 5%, or less than 5 Quads.
    B) Some; close to 20%, or just under 20 Quads.
    C) A surprisingly large amount: 59 Quads, or 60%!
    D) All of it; 100% of the energy is rejected as waste heat.

39. For the year 2015, compare the US consumption of energy by source: fossil fuels (petroleum, natural gas, coal), nuclear, and renewable (solar, wind, hydroelectric, etc.).
    A) All sources are fairly evenly split, with about 33% each for fossil fuels, nuclear, and renewables.
    B) The largest source by far is renewables, at about 81%, with fossil fuels at the lowest level, about 9%.
    C) Fossil fuels are dominant at 81%, while the nuclear and renewable categories are close to equal, at 9% and 10% respectively.
    D) There is no record of how much of each type of energy is consumed, so assigning percentages is a guess at best.