1. The wound-up spring has elastic potential energy, which is converted to kinetic energy, heat and sound as it unwinds and the parts of the clock move.
2. Initially there is stored chemical energy in the athlete. This is converted to kinetic energy as the athlete runs. As the pole bends kinetic energy is converted to elastic potential energy. As the pole straightens out its elastic potential energy is converted to gravitational potential energy. Falling back down this becomes kinetic energy and then eventually heat and sound after impact with the pad.
3. The truck's kinetic energy is somewhat transferred to the gravel rocks that are set into motion. Also some kinetic energy is transformed into gravitational potential energy as the truck moves uphill, slowing down.
4. Because values of position and velocity are dependent on frame of reference, so are the values of potential and kinetic energy. Depending on type of reference frame used, changes in energy may also be relative.
5. The clay loses kinetic energy but does not gain or lose gravitational potential energy. Instead the impact generates heat and sound that should equal the amount of kinetic energy lost.
6. a. 410 kJ
   b. 3.9 times more
7. 640 Megatons
   (2.7×10^{18} J)
8. a. 120 J
   b. –2700 J
9. a. 5.7 m
   b. 47 kg
10. a. 19.6 kJ
    b. 44.3 m/s
11. a. 2.0 J
    b. 4.1 m/s
12. a. $h = \dfrac{v^2}{2g}$

    b. $v = \dfrac{gT}{2\pi}\sqrt{2(1-\cos\theta)}$
13. a. 12.5 m/s
    b. 6000 J
    c. 1500 J
    d. 4500 J
    e. 10.8 m/s
14. a. 13.1 m/s
    b. 8.61 m/s
15. a. 165 J
    b. 25.7 m/s
    c. Neither result would be different because energy and speed are scalars and do not depend on direction.
16. 11.5 m, 2.81 J
17. a. Zero work is done if the object does not move or if it moves perpendicular to the direction of the force.
    b. Positive work is done if the object moves (at least somewhat) in the direction of the force.
    c. Negative work is done if the object moves (at least somewhat) in a direction opposite that of the force.
18. a. 800 J
    b. –780 J
19. 342
20. 12.0 kJ
21. 18 kJ
22. 7.7 J
23. a. 880 J
    b. –681 J
    c. 0 J
    d. –199 J
    e. 49.8 N
24. The KE will not equal PE! At terminal velocity the ball is losing PE but NOT gaining KE. Instead there is heat and sound generated due to the air resistance.
25. a. 250 MJ
    b. 140 m/s
26. a. –144 kJ
    b. 288 kN
27. 2700 N

28. 14.3 m/s
29. 26 m
30. a. −820 J
    b. 100 N
31. a. 0.583 m/s^2
    b. 0.242 m/s
    c. 0.650 s
32. a. 0.408 m
    b. 2.02 m/s
    c. 1.14 J
33. a. 13.0 kN/m; 16.9 m
    b. Not practical!
34. a. $K_{\max} = \dfrac{\pi^2 m d^2}{8T^2}$
    b. $v_{\max} = \dfrac{\pi d}{2T}$
35. a. Work is equal.
    b. Frank is more powerful.
36. a. 5500 J
    b. 0 J
    c. –5500 J
    d. Brutus does zero work if wts are dropped.
    e. 2200 W
37. a. 66 kW (89 hp)
    b. 700 N
38. a. 110 kJ
    b. 35 s
39. a. $P = mg^2t$
    b. $P = mg^2t\sin^2\theta$
    c. Car free falls for 0.52 s (for example, drives off a 1.3 m high dock and lands in a lake). There are other answers.
40. 90 kW
41. 2.89 kN (or 295 kg)
42. a. 376 kJ
    b. 8.40 minutes
43. a. 15 s
    b. 120 kJ
44. a. 37.0%
    b. 2.13
45. a. 74 N
    b. 82%
46. a. 546 N
    b. 89.5 kW
    c. 4.56 MJ
    d. 19 mpg