PHY2020 **Practice Problems** **Fall 2015**

Some of these "practice problems" are easy and some are not. Most of them should require between 5 and 15 minutes for you to solve. The more of them that you attempt on your own (whether successful or not) the better you will become at problem solving. If you spend more than 15 minutes unsuccessfully working on a problem, then I will happily help **you to solve** the problem during my office hours.

My official office hours are Tuesday and Wednesday at 3:00pm — **never** before class on MWF. At other times, if I'm not busy with something else, then I might spend a modest amount of time leading **you** in the proper direction.

1. (2 pts) A two meter long see-saw is balanced on a fulcrum in the middle. A girl of mass 40 kg sits at the end of the see-saw a distance 1 m from the fulcrum. A boy of mass 50 kg sits on the other side of the see-saw to balance the see-saw. How far is the boy from the fulcrum?

   Ans: 0.8 m

2. (2 pts) A spring is held compressed between a block M_1 of mass 1 kg and another block M_2 of mass 2 kg. The two blocks are then released simultaneously, they move in opposite directions on a frictionless surface, and M_1 is measured to have a speed of 2 m/s. What, then, is the speed of M_2?

3. (6 pts) A 4 kg mass and a 2 kg mass are attached to each other by a string which has a length of 3 m. The 4 kg mass is 1 m away from the center of mass of the system.

   (a) How far is the 2 kg mass from the center of mass of the system?

   (b) Each mass moves in a different circle about the common center of mass, and the 4 kg mass moves with a speed of 1 m/s. How fast does the 2 kg mass move about the center of mass?

   (c) What is the tension in the string?

4. (6 pts) How much work do you do if you lift an object of mass 10 kg off the ground to a height of 2 m?

   (a) How much work do you do if you slowly carry this 10 kg mass at the same height (2 m) to a new location 20 m away?

   (b) If you then drop the object and it falls to the ground, how fast will it be moving just before it hits the ground?

5. A monkey is hanging in a tree, and a hunter aims a blow gun directly at the monkey. At the instant the hunter shoots the dart, the monkey drops from the tree. Does the dart

   (a) hit the monkey,
   (b) pass above the monkey
   (c) or pass below the monkey?

6. Complete the following sentence: A bowling ball and a ping pong ball fall with the same acceleration in a vacuum on the surface of the earth

   (a) Even though the force of gravity is different on the two objects.
   (b) Because the force of gravity is the same on the two objects.
   (c) Only in a dark room.
   (d) Only on the North or South poles.

7. A sports car can accelerate at $5\,\mathrm{m/s^2}$.

   (a) How many seconds does it take to go from 0 to 30 m/s (about 70 mi/h)?
   (b) How far, in meters, does it travel in this time?

8. (4 pts) First you walk south 3 meters, then you walk east 4 meters.

   (a) What is the distance from where you started to where you stopped?

   Ans: 5 m

   (b) You were walking at a speed of 2 m/s, so how much time did it take for you to travel along that path?

   Ans: 3.5 s

9. (4 pts) You tie a rope around a tree trunk and pull with a force of 200 N.

   (a) What is the tension in the rope?

   Ans: 200 N

   (b) What is the magnitude of the force that the tree exerts on the rope?

   Ans: 200 N

10. (6 pts) A block of mass $M_5 = 5\,\text{kg}$ and a second block of mass $M_3 = 3\,\text{kg}$ are attached to each other by a string. The 3 kg block has a second string attached to it with a tension of 16 N which accelerates the combination of blocks to the right, as shown in the figure.

    (a) What is the acceleration of the 3 kg block?

    Ans: $2\,\text{m/s}^2$

    (b) What is the acceleration of the 5 kg block?

    Ans: $2\,\text{m/s}^2$

    (c) What is the tension in the string between the two masses?

11. (6 pts) Two blocks with masses $M_2 = 2\,\text{kg}$ and $M_4 = 4\,\text{kg}$ have a fire cracker placed between them. After the firecracker goes off M_4 is measured to have a speed 4 m/s.

    (a) What speed does M_2 have after the explosion?

    Ans: $v_2 = 8\,\text{m/s}$

    (b) What is the total kinetic energy of the two masses after the explosion?

    Ans: 96 J

    (c) Which mass has more kinetic energy after the explosion?
    Circle one of these choices:
    M_2 M_4 They have the same kinetic energy

12. (2 pts) A new planet has been discovered that has twice the mass of the Earth and has a radius twice the radius of the Earth. What is the acceleration of gravity (i.e. g) on the surface of this new planet?

    Ans: $5\,\text{m/s}^2$.

13. (4 pts) A block of mass 4 kg slides on a tabletop with no friction at a speed 3 m/s until it bangs into and sticks to a second block of mass 2 kg which was initially at rest. Together they continue to slide with a common speed v_f.

(a) What is the common speed v_f of the masses after the collision? Be certain to include the appropriate units on your answer.

Ans: $v_f = 2\,\mathrm{m/s}$

(b) How much kinetic energy was *lost* in the collision? Be certain to include the appropriate units on your answer.

Ans: 6 J were lost in the collision.

14. (2 pts) A balance beam 1 m long has a fulcrum in the middle. A 3 kg mass hangs at the far left hand end of the beam, and a 2 kg mass hangs at the far right hand end of the beam. Where on the beam should you hang a second 2 kg mass so that the arrangement of masses will balance. Give your answer as the distance as measured from the left hand end of the beam.

15. (6 pts) A hand grenade with a mass of 3 kg explodes into two pieces. One piece has a mass of 1 kg and moves with a speed of 40 m/s.

(a) What is the mass of the second piece of the hand grenade?

Ans: 2 kg.

(b) How fast is the second piece moving after the explosion?

Ans: 20 m/s.

(c) Which of the two parts of the hand grenade has more kinetic energy after the explosion?

Ans: The 1 kg mass.

16. (2 pts) An airplane flies in a horizontal circle of radius $R = 500\,\mathrm{m}$ with a constant speed of $v = 100\,\mathrm{m/s}$. What is the magnitude of the acceleration of the airplane?

Ans: $20\,\mathrm{m/s^2}$

17. (2 pts) A new planet orbiting Alpha Centauri (the star nearest to our Sun) has a mass one half the mass of the Earth and has a radius one half the radius of the Earth. What is the acceleration of gravity (i.e. g) on the surface of this new planet?

Ans: $g_{\mathrm{Earth}} = GM_E/R_E^2$, so for the new planet $g_{\mathrm{new}} = G(M_E/2)/(R_E/2)^2 = 2 \times (GM_E/R_E^2) = 20\,\mathrm{m/s^2}$.

18. (2 pts) A two meter long see-saw is balanced on a fulcrum in the middle. A girl of mass 40 kg sits at the end of the see-saw a distance 1 m from the fulcrum. A boy of mass 50 kg sits on the other side of the see-saw to balance the see-saw. How far is the boy from the fulcrum?

19. A new planet has been discovered that has twice the mass of the Earth and has a radius twice the radius of the Earth. What is the acceleration of gravity on the surface of this new planet?

20. (4 pts) Typical walking speed depends upon the length ℓ of your leg (which determines how long each step is) and also upon the average time T that a single step takes, where a pendulum of length ℓ has a natural period of $T = 2\pi\sqrt{\ell/g}$.

21. Would you walk "faster" or "slower" if your legs were longer?

    Ans: faster

22. If your natural walking speed is v_0, what would your natural walking speed be if your legs were twice as long?

    Ans: $v \sim \ell/T \sim \ell/(2\pi\sqrt{\ell/g}) \sim \sqrt{g\ell}/2\pi$, so if your legs were twice as long ($\ell \to 2\ell$ in the previous formula) your walking speed would increase by $\sqrt{2}$.

23. "Power" is a technical word in physics that refers to the rate at which energy is used, or work is performed. A common unit of power is a "Watt" which is defined as

$$1\,\text{Watt} = 1\,\text{Joule/sec.}$$

    A common unit of energy is 1 kilowatt-hour = $3,600,000$ Joules. If your mass is 60 kg, and you walk up the stairs to the top of the Statue of Liberty (a height of 100 m) in 1 hour (3,600 seconds) then how much energy did you use in units of Joules?

24. And, how much energy did you use in units of kilowatt-hours? (As a side note, 1 kwh costs between 10 and 20 cents.)

25. A 5 kg block is at rest on a table top. What is the magnitude of the sum of all of the forces acting on the block? This is also called the "net force."

    Ans: zero

26. Two children slide down a frictionless slide at a playground. One child has a mass of 30 kg and slides down the slide in 3 s. The other child has a mass of 60 kg. How much time will it take the second child to slide down the slide?

    Ans: 3 s

27. Your mass is 60 kg, and you are standing on a platform on the surface of the Earth. What is the magnitude of the force of gravity acting upon you?

    Ans: 600 N.

28. What is the magnitude of the sum of all of the forces acting upon you? zero.

29. An object of mass 20 kg is acted upon by three forces. One force is 3 N to the right, the second is 5 N to the left. The object moves with a constant speed of 4 m/s to the right. What is the magnitude and the direction (left or right) of the third force?

    Ans: 2 N to the right.

30. A new planet orbiting Alpha Centauri (the star nearest to our Sun) has a mass one half the mass of the Earth and has a radius one half the radius of the Earth. What is the acceleration of gravity (i.e. g) on the surface of this new planet?

    Ans: $20\,\mathrm{m/s^2}$.

31. A block of mass m slides with no friction at a speed v_i until it bangs into and sticks to a second block, also of mass m. Together they continue to slide with a common speed v_f. What is the speed v_f of the masses after the collision? Give your answer in terms of m and v_i.

    Ans: $v_f = v_i/2$

32. How much kinetic energy was lost in the collision? Give your answer *only* in terms of m and v_i, and specifically not in terms of v_f.

    Ans: $\frac{1}{2}K.E._i$ was lost.

33. (4 pts) "Power" is a technical word in physics that refers to the rate at which energy is used, or work is performed. A common unit of power is a "Watt" which is defined as

    $$1\,\text{Watt} = 1\,\text{Joule/sec.}$$

    A common unit of energy is 1 kilowatt-hour = 3,600,000 Joules. If your mass is 60 kg, and you walk up the stairs to the top of the Statue of Liberty (a height of 100 m) in 1 hour (3,600 seconds) then how much energy did you use in units of Joules?

34. And, how much energy did you use in units of kilowatt-hours? (As a side note, 1 kwh costs between 10 and 20 cents.)

35. Shown in the diagram below are three separate pairs of charges. Assume that each member of a pair only interacts with its partner. Rank the magnitudes of the forces between the pairs from largest to smallest. The appropriate diagram appears on a separate sheet of paper.

36. The potential difference between a storm cloud and and the ground is 10^8Volts. If a charge of two Coulombs flashes in a lighting bolt, what is the change in the potential energy of the charge?

37. Two point charges are separated by 6 centimeters. The attractive force between them is 20 N. Find the force between them when they are separated by 12 centimeters.

38. With electric charges we typically ignore the force of the Earth's gravity. To see why, compute the force of gravity on the electron, and then compare it with the force exerted by an electric field of 10^4 V/ m, which is a relatively small small electric field.

39. There are about 5×10^{22} freely moving electrons in a penny. Why don't they fly out of the penny?

40. How does the magnitude of the electrical force between a pair of charged particles change when the particles are moved to be half as far apart? How does the force change if they are moved to be one third as far apart?

41. Assume that you have a pair of identical charged particles. If you double the charge on one of the particles, what effect does this have on the force between them? Or if you change the sign of the charge of one of the particles how does the force between them change?

42. If you expend 10 J of work to push 1 C against an electric field, what is the change in the charge's voltage?

43. If you then release the charge of the particle, in the preceding problem, how much kinetic energy does the particle have when it rapidly moves by its initial position?

44. A vector describing a gravitational field points toward the center of the Earth. Why does the electric field vector of a proton point away from the proton?

45. If electrons had positive charge, and protons had negative charge, how would Coulomb's law be written?

46. What happens to the other light bulbs, if one light bulb in a series circuit burns out?

47. What happens to the brightness of the other bulbs in a series circuit, if an additional light is added in series?

48. What happens to all of the other light bulbs, if one light bulb in a parallel circuit burns out?

49. What happens to the brightness of the other bulbs in a parallel circuit, if an additional light is added in parallel?

50. What happens to the current in the battery, when more bulbs are added in parallel?

51. If the voltage impressed across a circuit is held constant while the resistance doubles, what change occurs in the current?

52. If the resistance of a circuit remains constant while the voltage across the circuit decreases to half its former value, what change occurs in the current?

53. If you touch your finger (resistance 1000 Ohms) to the terminals of a 6 Volt battery, what is the size of the current that flows through your finger.

54. Only a small percentage of the electrical energy fed into a common light bulb is transformed into light. What happens to the rest of the energy.