Practice problems for Test #2
Chapters 5-8

These problems are for practice only, and cover *most* of the material, but not necessarily all of the material. Problems on the test are guaranteed to be *similar*, but not identical.

1. Two 25.0-N weights are suspended at opposite ends of a rope that passes over a light, frictionless pulley. The pulley is attached to a chain that goes to the ceiling. (a) What is the tension in the rope? (b) What is the tension in the chain? (ans: a) 25.0 N; b) 50.0 N)

2. On September 8, 2004, the Genesis spacecraft crashed in the Utah desert because its parachute did not open. The 210-kg capsule hit the ground at 311 km/h and penetrated the soil to a depth of 81.0 cm. (a) Assuming it to be constant, what was its acceleration (in m/s^2 and in g's) during the crash? (b) What force did the ground exert on the capsule during the crash? Express the force in newtons and as a multiple of the capsule's weight. (c) For how long did this force last? (ans: a) 4610 m/s^2, 470g; b) 9.70×10^5 N, 471w; c) 18.7 m/s)

3. The first two steps in the solution of Newton's second-law problems are to select an object for analysis and then to draw free-body diagrams for that object. Draw free-body diagrams for the following situations: (a) a mass M sliding down a frictionless inclined plane of angle α and (b) a mass M sliding up a frictionless inclined plane of angle α; (c) a mass M sliding up an inclined plane of angle α with kinetic friction present.

4. A machine part consists of a thin 40.0-cm-long bar with small 1.15-kg masses fastened by screws to its ends. The screws can support a maximum force of 75.0 N without pulling out. This bar rotates about an axis perpendicular to it at its center. (a) As the bar is turning at a constant rate on a horizontal frictionless surface, what is the maximum speed the masses can have without pulling out the screws? (b) Suppose the machine is redesigned so that the bar turns at a constant rate in a vertical circle. Will one of the screws be more likely to pull out when the mass is at the top of the circle or at the bottom? Use a free-body diagram to see why. (c) Using the result of part (b),what is the greatest speed the masses can have without pulling a screw? (ans: 3.61 m/s; b) bottom; c) 3.33 m/s)

5. An old oaken bucket of mass 6.75 kg hangs in a well at the end of a rope. The rope passes over a frictionless pulley at the top of the well, and you pull horizontally on the end of the rope to raise the bucket slowly a distance of 4.00 m. (a) How much work do you do on the bucket in pulling it up? (b) How much work does gravity do on the bucket? (c) What is the total work done on the bucket? (ans: a) 3.60 J; b) -0.900 J; c) 2.70 J)

6. The mass of a proton is 1836 times the mass of an electron. (a) A proton is traveling at speed V. At what speed (in terms of V) would an electron have the same kinetic energy as the proton? (b) An electron has kinetic energy K. If a proton has the same speed as the electron, what is its kinetic energy (in terms of K)? (ans: a) $42.85V$; b) $1836K$)

7. A force of 160 N stretches a spring 0.050 m beyond its unstretched length. (a) What magnitude of force is required to stretch the spring 0.015 m beyond its unstretched length? To compress the spring 0.020 m? (b) How much work must be done to stretch the spring 0.015 m beyond its unstretched length? To compress the spring 0.020 m from its unstretched length? (ans: a) 48.0 N, 64.0 N; b) 0.360 J, 0.640 J)

8. A 6.0-kg box moving at 3.0 m/s on a horizontal, frictionless surface runs into a light spring of force constant 75 N/cm. Use the work-energy theorem to find the maximum compression of the spring. (ans: 8.5 cm)

9. How many joules of energy does a 100-watt light bulb use per hour? How fast would a 70-kg person have to run to have that amount of kinetic energy? (ans: 3.6×10^5 J, 100 m/s)

10. In one day, a 75-kg mountain climber ascends from the 1500-m level on a vertical cliff to the top at 2400 m. The next day, she descends from the top to the base of the cliff, which is at an elevation of 1350 m. What is her change in gravitational potential energy (a) on the first day and (b) on the second day? (ans: a) 6.6×10^5 J; b) -7.7×10^5 J)

11. A spring of negligible mass has force constant $k = 1600$ N/m. (a) How far must the spring be compressed for 3.20 J of potential energy to be stored in it? (b) You place the spring vertically with one end on the floor. You then drop a 1.20-kg book onto it from a height of 0.80 m above the top of the spring. Find the maximum distance the spring will be compressed. (ans: a) 6.32 cm; b) 12 cm)

12. A 10.0-kg box is pulled by a horizontal wire in a circle on a rough horizontal surface for which the coefficient of kinetic friction is 0.250. Calculate the work done by friction during one complete circular trip if the radius is (a) 2.00 m and (b) 4.00 m. (c) On the basis of the results you just obtained, would you say that friction is a conservative or nonconservative force? Explain. (ans: a) -308 J; b) -616 J; c) nonconservative)

13. A force parallel to the x-axis acts on a particle moving along the x-axis. This force produces potential energy $U(x)$ given by $U(x) = \alpha x^4$, where $\alpha = 1.20$ J/m^4. What is the force (magnitude and direction) when the particle is at $x = -0.800$ m? (ans: 2.46 N, $+x$-direction)

14. A 0.100-kg potato is tied to a string with length 2.50 m, and the other end of the string is tied to a rigid support. The potato is held straight out horizontally from the point of support, with the string pulled taut, and is then released. (a) What is the speed of the potato at the lowest point of its motion? (b) What is the tension in the string at this point? (ans: a) $mg\left(1 - \frac{h}{d}\right)$; b) 440 N)

15. (a) What is the magnitude of the momentum of a 10,000-kg truck whose speed is 12.0 m/s. (b) What speed would a 2,000-kg SUV have to attain in order to have (i) the same momentum? (ii) the same kinetic energy? (ans: a) 1.20×10^5 kg $\cdot$ m/s; b) i) 60.0 m/s, ii) 26.8 m/s)

16. A 0.0450-kg golf ball initially at rest is given a speed of 25.0 m/s when a club strikes. If the club and ball are in contact for 2.00 ms, what average force acts on the ball? Is the effect of the ball's weight during the time of contact significant? Why or why not? (ans: 562 N, no)

17. The expanding gases that leave the muzzle of a rifle also contribute to the recoil. A.30-caliber bullet has mass 0.00720 kg and a speed of 601 m/s relative to the muzzle when fired from a rifle that has mass 2.80 kg. The loosely held rifle recoils at a speed of 1.85 m/s relative to the earth. Find the momentum of the propellant gases in a coordinate system attached to the earth as they leave the muzzle of the rifle. (ans: 0.866 kg $\cdot$ m/s)

18. In July 2005, NASA's "Deep Impact" mission crashed a 372-kg probe directly onto the surface of the comet Tempel 1, hitting the surface at 37,000 km/h. The original speed of the comet at that time was about 40,000 km/h, and its mass was estimated to be 0.1×10^{14} kg. (a) What change in the comet's velocity did this collision produce? Would this change be noticeable? (b) Suppose this comet were to hit the earth and fuse with it. By how much would it change our planet's velocity? Would this change be noticeable? (ans: a) 1.4×10^{-6} km/h, not noticable; b) 6.7×10^{-8} km/h, not noticable)

19. A 10.0-g marble slides to the left with a speed of 0.400 m/s on the frictionless, horizontal surface of an icy New York sidewalk and has a head-on, elastic collision with a larger 30.0-g marble sliding to the right with a speed of 0.200 m/s. (a) Find the velocity of each marble (magnitude and direction) after the collision. (Since the collision is head-on, all the motion is along a line.) (b) Calculate the change in momentum (that is, the momentum after the collision minus the momentum before the collision) for each marble. Compare the values you get for each marble. (c) Calculate the change in kinetic energy (that is, the kinetic energy after the collision minus the kinetic energy before the collision) for each marble. Compare the values you get for each marble. (ans: a) -0.100 m/s, 0.500 m/s; b) 0.009 kg $\cdot$ m/s for both; c) -4.5×10^{-4} J, 4.5×10^{-4} J)

20. Find the location of the center of mass of the Earth-Moon system.

21. If the coefficient of static friction between a table and a uniform massive rope is μ_s what fraction of the rope can hang over the edge of the table without the rope sliding?

22. A pump is required to lift 800 kg of water (about 210 gallons) per minute from a well 14.0 m deep and eject it with a speed of 18.0 m/s. (a) How much work is done per minute in lifting the water? (b) How much work is done in giving the water the kinetic energy it has when ejected? (c) What must be the power output of the pump?