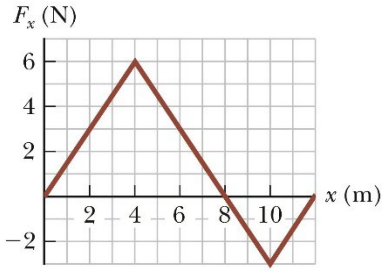
University Physics I

Homework Set 9

1. In 1990, Walter Arfeuille of Belgium lifted a 281.5 *kg* object through a distance of 17.1 *cm* using only his teeth.
    a. How much work was done on the object by Arfeuille during the lift (*assuming constant velocity*)?
    b. What total force was exerted on Arfeuille's teeth during the lift?
2. The record number of boat lifts, including the boat and its ten crew members, was achieved by Sami Heinonen and Juha Räsänen of Sweden in 2000. They lifted a total mass of 653.2 *kg* approximately 4 *in*. off the ground a total of 24 times. Estimate the total work done by the two men on the boat in this record lift (*ignore the negative work done by the men when they lowered the boat back to the ground and assume the lift was at constant velocity each time*).
3. Vector **A** has a magnitude of 5.00 units, and vector **B** has a magnitude of 9.00 units. The two vectors make an angle of 50.0° with respect to each other. Find **A**·**B**.
4. A force $\mathbf{F} = (6\,\hat{\boldsymbol{x}} - 2\,\hat{\boldsymbol{y}})$ N acts on a particle that undergoes a displacement of $\Delta\mathbf{r} = (3\,\hat{\boldsymbol{x}} + \hat{\boldsymbol{y}})$ *m*. Find:
    a. The work done by the force on the particle
    b. The angle between **F** and $\Delta\mathbf{r}$
5. The force acting on a particle varies as shown in the figure at right. Find the work done by the force on the particle as it moves
    a. From $x = 0$ to $x = 8.00$ *m*
    b. From $x = 8.00$ *m* to $x = 10.0$ *m*
    c. From $x = 0$ to $x = 10.0$ *m*



6. A spring with force constant 3.85 N/*m* is compressed by 8.00 *cm* as it is held between a 0.250 *kg* block on the left and a 0.500 *kg* block on the right, both resting on a horizontal surface. The spring exerts a force on each block trying to push them apart. If the blocks are simultaneously released from rest, find the initial acceleration (*if any*) for each block if the coefficient of kinetic friction between each block and the surface is:
    a. 0
    b. 0.100
    c. 0.462
7. To help get a sense of scale, determine the amount of kinetic energy each of the following objects possess:
    a. An electron in the ground state of a hydrogen atom that has an orbital speed of 2190 *km/s*
    b. A 1200 *kg* car traveling at 70 *mph*
    c. A 90 *kg* football player that runs a 4.15 in the 40. (*meaning, they can run 40 yards in 4.15 seconds*)
    d. A 9 *mm* bullet (7.5 g) with a muzzle velocity of 1247 *ft/s*
    e. An Adult cheetah (70 *kg*) that has been clocked to run at up to 72 *mph*

8. About 50,000 years ago, a meteor crashed into the earth near present-day Flagstaff, Arizona. Measurements from 2005 estimate that this meteor had a mass of about 1.4×10^8 *kg* and hit the ground at a speed of 12 *km*/*s*.
    a. How much kinetic energy did this meteor deliver to the ground?
    b. How does this energy compare to the energy released by a 1.0 megaton nuclear bomb?

    (A megaton bomb releases the same amount of energy as a million tons of TNT, and 1 ton of TNT releases 4.184×10^9 J of energy.)

9. A bullet moving at a speed of 153 *m*/*s* passes through a plank of wood. After passing through the plank, its speed is 130 *m*/*s*. Another bullet, of the same mass and size is moving at 92.0 *m*/*s*, passes through an identical plank. Assuming the resistance offered by the plank is independent of the speed of the bullet, what will be the second bullets final speed as it emerges from the plank?

10. A particle of mass *m* is subjected to a force acting in the *x*-direction, $F_x = (3.00 + 0.500x)$ N. Find the work done by the variable force as the particle moves from $x = 0.00$ to $x = 4.00$ *m*.

11. A surgeon is using material from a donated heart to repair a patient's damaged aorta and needs to know the elastic characteristics of the new aorta. Test's performed on a 16.0 *cm* strip of the donated aorta reveal that it stretches 3.75 *cm* when a 1.50 N pull is exerted on it.
    a. What is the force constant of this strip of aortal material?
    b. If the maximum distance it will be able to stretch when it replaces the aorta in the damaged heart is 1.14 *cm*, what is the greatest force it will be able to experience there?

12. On December 27, 2004, astronomers observed the greatest flash of light ever recorded from outside the solar system. It came from the highly magnetic neutron star SGR 1806-20 (*a magnetar*). During the 0.20 *s*, this star released as much energy as our sun does in 250,000 years. If P_{sun} is the average power output of our sun, what was the average power output (*in terms of* P_{sun}) of this magnetar?

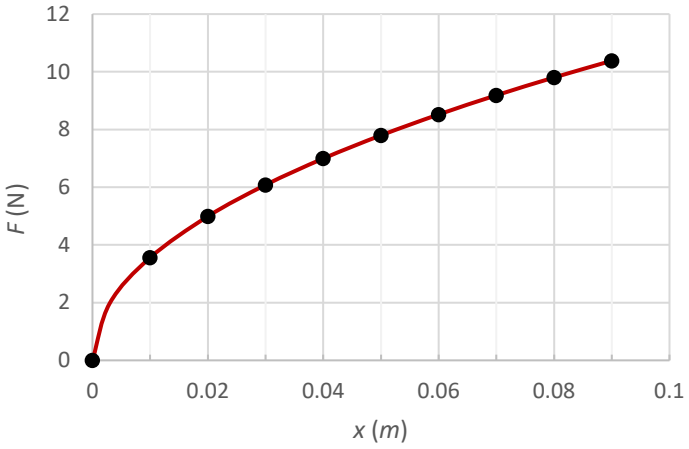
13. When an automobile moves with constant speed down the highway, most of the power developed by the engine is used to compensate for the energy transformations due to friction forces exerted on the car by the air, road, and slight deformation of the tires. If the power developed by an engine is 175 *hp*, estimate the total friction force acting on the car when it is moving at a speed of 29 *m*/*s*.

14. ** It is 5.0 *km* from your home to the physics lab. As part of your physical fitness program, you could either run or walk to the lab daily. Running at a rate of 10 *km*/*h* would burn energy at a rate of 700 W. Walking at a leisurely pace of 3.0 *km*/*h* would burn 290 W. If your goal was to burn as much energy as possible, would it be better to walk or run? Does your answer surprise you? Explain.

15. ** Energy is conventionally measured in Calories as well as joules. One food Calorie in nutrition is one kilocalorie of energy (1 *kcal* = 4186 J). Metabolizing 1 *g* of fat can release 9.00 *kcal* of energy. Suppose a 75.0 *kg* student describes a way to lose weight by exercising, in which he plans to run up and down the stairs in a football stadium as fast as he can and as many times as necessary. To evaluate the program, suppose he runs up a flight of 80 steps, each 0.150 *m* high, in 65.0 *s* at a constant rate. For simplicity, ignore the energy he uses in coming down (*which is small*). Also assume a typical efficiency for human muscles of 20.0%. (*This statement means that when your body converts* 100 J *from metabolizing fat,* 20 J *goes into doing mechanical work (here, climbing stairs). The remainder goes into extra internal energy used by the body and cells*).

   a. How many times must the student run the flight of stairs to lose 1.00 *kg* (2.2 *lbs*) of fat?
   b. What is his average power output (in W and *hp*) as he runs up the stairs?
   c. How long (*in hours*) would it take under these conditions to lose the 1.00 kg of fat?
   d. Does this activity in itself seem like a practical way to lose weight?

16. ** The figure below shows the results of measuring the force F exerted on both ends of a rubber band to stretch it a distance *x* from its unstretched position (www.sciencebuddies.org). The data points are well fit by the equation $F = 33.55\, x^{0.4871}$, where *F* is in newtons and *x* is in meters.



   a. Does this rubber band obey Hooke's law over the range of *x* shown in the graph? Explain.
   b. The stiffness of a spring that obeys Hooke's law is measured by the value of its force constant *k*, where $k = F/x$. Define $k_{eff} = dF/dx$ and calculate k_{eff} as a function of *x* for this rubber band. Does the stiffness of this rubber band, as measured by k_{eff}, increase, decrease or remain constant as *x* is increased, within the range of data?
   c. How much work must be done to stretch the rubber band from $x = 0$ to $x = 0.0400$ *m*? From $x = 0.0400$ *m* to $x = 0.0800$ *m*?
   d. One end of the rubber band is attached to a stationary vertical rod and the band is stretched horizontally 0.0800 *m* from its unstretched length. A 0.300 *kg* object on a horizontal, frictionless surface is attached to the free end of the rubber band and released from rest. What is the speed of the object after it has traveled 0.0400 *m*?