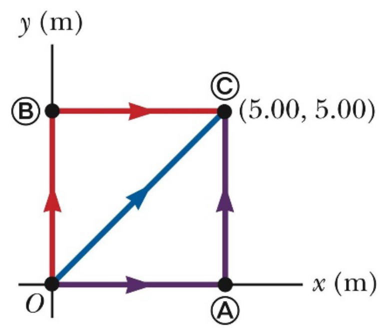
## University Physics I

*Homework Set 10*

1. A 1.50 *kg* ball has a speed of 20.0 *m*/*s* when it is moving 15.0 *m* horizontally above the ground. If $U = 0$ is taken to be at ground level, what is the total mechanical energy of the ball?

2. A 400 N child is in a swing that is attached to a pair of ropes 2.00 *m* long. Find the gravitational potential energy of the child relative to the child's lowest position in the swing when
   *a.* The ropes are horizontal
   *b.* The ropes make a 30.0$^{o}$ angle with the vertical
   *c.* The child is at the bottom of the arc

3. A 4.00 *kg* particle moves from the origin to position ©, having $(x, y)$ coordinates of (5.00, 5.00) *m* as shown at right. One force on the particle is the gravitational force acting in the negative $y$ direction. Using $W = F\Delta r\cos\theta$, calculate the work done by the gravitational force on the particle as it goes from the origin O to © along:

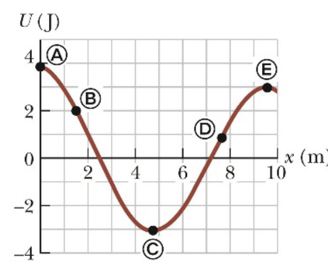



   *a.* The purple path
   *b.* The red path
   *c.* The blue path
   *d.* Should all your results be the same? Explain

4. A 4.00 *kg* particle moves from the origin to position ©, as shown above, under the influence of a single force given by $\mathbf{F} = (2y\,\hat{\boldsymbol{x}} + x^2\,\hat{\boldsymbol{y}})$ N. Calculate the work done by this force on the particle as it goes from the origin O to © along:
   *a.* The purple path
   *b.* The red path
   *c.* The blue path
   *d.* Is **F** a conservative or non-conservative force? Explain

5. A single conservative force, given by $F_x = (2x + 4)$ N, acts on a 5.00 *kg* particle within a system due to its interaction with the rest of the system. As the particle moves along the x axis from $x = 1.00$ *m* to $x = 5.00$ *m*, calculate:
   *a.* The work done by this force on the particle
   *b.* The change in the potential energy of the system
   *c.* The kinetic energy of the particle at $x = 5.00$ *m* if its speed at $x = 1.00$ *m* was 3.00 *m*/*s*.
   *d.* Plot $U(x)$ vs $x$. Indicate the location of stable or unstable equilibrium points (*if any*).

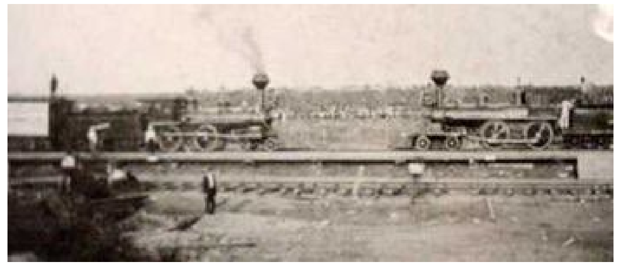
6. ** For the potential energy curve shown at right:




   *a.* Determine if the force acting on the particle is positive, negative or zero at all five locations
   *b.* Which of the point(s) represent a position of stable equilibrium (*if any*)?
   *c.* Which of the point(s) represent a position of unstable equilibrium (*if any*)?

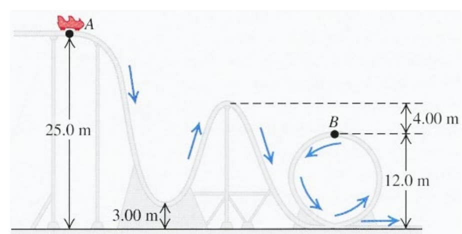
7. A basketball of mass 0.624 *kg* is shot from a vertical height of 1.20 *m* and at a speed of 20.0 *m/s*. After reaching its maximum height, the ball moves into the hoop on its downward path, at 3.05 *m* above the ground. Using the principle of energy conservation, determine how fast the ball is moving just before it enters the hoop.

8. In 1896 in Waco, Texas, William George Crush, owner of the K-T (or "Katy") railroad, parked two locomotives at opposite ends of a 6.4 *km* long track, fired them up, tied their throttles wide open, and then allowed them to crash head on at full speed in front of 30,000 spectators. Hundreds of people were injured by flying debris and a few were killed. Assuming that each locomotive weighed $1.2 \times 10^6$ N and it acceleration along the track was a constant 0.26 $m/s^2$, what was the total kinetic energy of the two locomotives just before the collision?

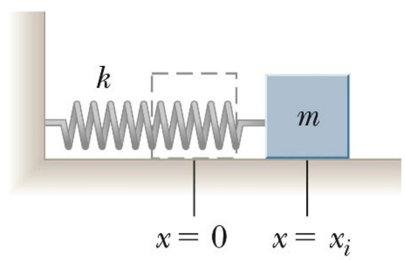


9. A block of mass 0.250 *kg* is placed on top of a light, vertical spring that has a force constant of 5,000 N/*m* and is compressed downward by 0.100 *m*. After the block is released from rest, it travels upward and leaves the spring. To what maximum height above the point of release does it rise?

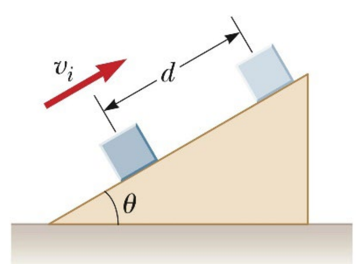
10. A 350 *kg* roller coaster starts from rest at point *A* and slides down a frictionless loop-the-loop as shown at right.
    *a.* How fast is the roller coaster going at point *B*?
    *b.* What is the change in potential energy between points A and B?




11. A block of mass $m = 2.00$ *kg* is attached to a spring with a force constant $k = 500$ N/*m* as shown at right. The block is pulled 5 *cm* to the right of its initial equilibrium position and released from rest. Find the speed of the block as it passes through the equilibrium position ($x = 0$) if:
    *a.* The horizontal surface is frictionless
    *b.* The coefficient of kinetic friction between the block and the surface is 0.350

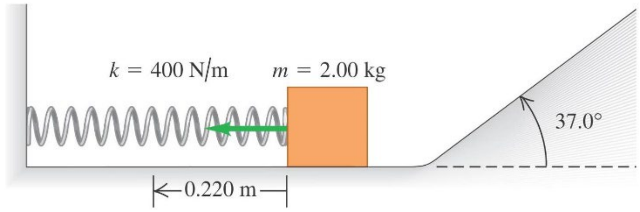



12. A 5.00 *kg* block is set into motion up an incline plane with an initial speed of 8.00 *m/s* as shown in the figure at right. The block comes to rest after traveling $d = 3.00$ *m* up the incline, which is at an angle of 30.0º. For this motion, determine:
    *a.* The change in the block's kinetic energy (ΔKE)
    *b.* The change in the block's potential energy (ΔU)
    *c.* The magnitude of the friction force exerted on the block (*assumed to be constant*)
    *d.* The coefficient of kinetic friction ($\mu_k$)



13. ** The potential energy of a pair of hydrogen atoms separated by a large distance $x$ is given by $U(x) = -C/x^6$, where $C$ is a positive constant.
    *a.* What is the force on atom exerts on the other?
    *b.* Is this force attractive or repulsive?

14. A 2.00 *kg* block is pushed against a spring with negligible mass and a force constant of $k$ = 400 N/*m*, compressing it 0.220 *m*. When the block is released, it moves along a frictionless, horizontal surface and then up a frictionless incline with a slope of 37.0º as shown in the figure at right.




    *a.* What is the speed of the block as it slides along the horizontal surface?
    *b.* How far up the incline does the block travel before coming to rest?

15. A circular wind turbine on a wind farm turns in response to a force of high speed air resistance, $R = ½D\rho Av^2$. The power available is $P = Rv = ½D\rho\pi r^2v^3$, where $v$ is the wind speed and $r$ is the radius of the circular wind turbine. Take the drag coefficient $D$ to be 1.00 and the density ($\rho$) of air as 1.20 $kg/m^3$. If $r$ = 1.50 *m*, calculate the power available if:
    *a.* The speed $v$ is equal to 8.00 *m*/*s*
    *b.* The speed $v$ is equal to 24.0 *m*/*s*

    The actual power delivered is limited by the efficiency of the system, which is typically only about 25%. The average American home uses about 1.2 kW of electric power per day. Assuming a daily sustained wind speed, determine many houses could be powered if
    *c.* The speed $v$ is equal to 8.00 *m*/*s*
    *d.* The speed $v$ is equal to 24.0 *m*/*s*

16. ** You are designing a pendulum for a science museum. The pendulum is made by attaching a brass sphere with mass m to the lower end of a long, light metal wire of (*unknown*) length $L$. A device near the top of the wire measures the tension in the wire and transmits that information to your laptop. When the wire is vertical and the sphere is at rest directly below, the spheres center is 0.800 *m* above the floor ($h_o$) and the tension in the wire is 265 N. Keeping the wire taut, your then pull the sphere to one side and gently release it. You record the height $h$ of the center of the sphere relative to the ground ($h$ = 0) and the tension $T$ in the wire as the sphere swings. Your results are shown in the following table:

| $h$ (*m*) | 0.800 | 2.00 | 4.00 | 6.00 | 8.00 | 10.0 | 12.0 |
|---|---|---|---|---|---|---|---|
| $T$ (N) | 265 | 274 | 298 | 313 | 330 | 348 | 371 |

*Assume the sphere can be modeled as a point particle of mass m and ignore the mass of the wire.*

    *a.* Use the sum of forces at the bottom of the swing and the conservation of mechanical energy to determine Tension ($T$) as a function of height ($h$).
        ***Hint:*** *Set the sum of the forces when finding T equal to $mv^2/r$ rather than ma.*
    *b.* Plot $T$ *vs* $h$ and use a trendline to determine $L$.
    *c.* If the breaking strength of the wire is 822 N, from what maximum height can the sphere be released if the tension in the wire is not to exceed half the breaking strength?
    *d.* What angle does the height determined in part *c* make with the vertical?