1) A cone is oriented with its axis vertical and its tip at its lowest point (so that the widest part of the cone is uppermost). The cone has an opening angle $\theta$ (the angle between the sides and the axis). A small object of mass $m$ moves without friction and with constant speed $v$ in a horizontal circle on the inside of the cone. Make a diagram of the forces acting on the object and then derive an expression for $r$, the radius of the circle, in terms of the given quantities and $g$.

2) **Text Problem 2-27** – note that an integral is required here.

3) **Text Problem 2-29**

4) **Text Problem 2-30** – note that there are two solutions to the quadratic equation for $h$, but that only one of them solves the original equation for the total time.

5) A projectile is launched at an initial inclination angle $\theta_o=36.9^o$ toward a vertical barrier of height $h_1=15.0$ m. The barrier is located at a horizontal distance $d_1=85.0$ m from the launch point and is at the edge of a cliff of height $h_2=35.0$ m. After clearing the barrier, the projectile travels an additional horizontal distance $d_2$ before hitting the ground at the bottom of the cliff (a vertical distance $h_1+h_2$ below the top of the barrier).

   a) Find the magnitude of the initial velocity $v_o$ so that the projectile just clears the top of the barrier. Neglect air resistance and do not assume that the top of the projectile's trajectory is at the top of the barrier.

   b) Using the initial velocity determined in part a, find $d_2$. 
6) A projectile is fired with initial speed \(v_0\) and initial inclination angle \(\alpha\) up a hill with slope \(\beta\), where \(\alpha > \beta\) and both angles are measured with respect to the horizontal.

a) Show that the distance up the slope where the projectile lands, measured from the launch point, is given by the expression

\[
\ell = \frac{2v_0^2 \cos \alpha \sin(\alpha - \beta)}{g \cos^2 \beta}
\]

b) For fixed slope angle \(\beta\), find the initial inclination angle \(\alpha\) that makes \(\ell\) maximum.

c) Show that your result for part b yields \(l_{\text{max}} = \frac{v_0^2}{g(1 + \sin \beta)}\)

7) A particle moves in a one-dimensional potential well with potential energy

\[
U(x) = U_0 \left[2(\frac{x}{a})^2 - (\frac{x}{a})^4\right]
\]

a) Find the force acting on the particle within the potential well.

b) Determine the equilibrium positions of the particle. Which of these are stable and which unstable?

c) What minimum velocity, \(v_{\text{esc}}\), must the particle have at \(x=0\) in order to escape from the well?

d) At time \(t=0\) the particle is at \(x=0\) and has velocity \(v=v_{\text{esc}}\). Use energy conservation to find \(v\) when the particle is at position \(x>0\).

e) Integrate the equation that results when the solution to part d is substituted into the relation \(v=dx/dt\) to show that at time \(t\),

\[
x = a \tanh(\alpha t) \quad \text{where} \quad \alpha^2 = \frac{2U_0}{ma^2}
\]