# Kinematics Problems

1. Find the ratio of the maximum height $H$ of a projectile launched from the ground to its range $R$. The projectile is launched with initial velocity $v_0$ and at an angle $\theta$. At what angle is $H = R$?

2. A cannon rests at the bottom of a flat hill that has an incline of angle $\phi$ with the ground. Given an initial velocity $v_0$, at what angle, measured from the hill, should the cannonball be launched so that its range $R$ up the hill is maximized?

3. The acceleration at a certain point of a rotating centrifuge is $kg$, where $k$ is some positive constant. What is the speed at this point? What is the frequency of revolutions required to produce this acceleration?

4. Neutron stars, which are extremely dense, spin with an angular velocity of $\omega$. If the radius of the neutron star is $R$ (which is also generally very small, under 100 km), then what is the speed at the equator of the star, provided it is spherical? What is the centripetal acceleration at this point?

5. A particle moves in a plane according to the following equations:

$$x = R\sin\omega t + R\omega t$$

$$y = R\cos\omega t + R$$

What is the velocity and acceleration in the x and y-directions as a function of time? What are the normal and tangential components of the acceleration?

6. A pilot is supposed to fly due east from point $A$ to point $B$ and then back again to $A$ due west. The velocity of the plane in the air is $v$ and the velocity of the air with respect to the ground is $u$. Both velocities are horizontal. The distance between $A$ and $B$ is $L$. What is the total time of the trip? Suppose that the air velocity points north. What is the total time of the trip now? Assume $u < v$.

All of these problems or very similar problems came from the book "Physics, 4th. ed, vol. 1" by Resnick, Halliday, and Krane.