Physics Club Handout 1: Motion

For all these problems, assume acceleration due to gravity is $9.81\frac{\text{m}}{\text{s}}$.

Beginner problems:

1. An automobile traveling at $10\frac{\text{m}}{\text{s}}$ accelerates to $20\frac{\text{m}}{\text{s}}$ in 10 seconds. How far does the automobile travel during that time?

2. A roller-coaster car moves 200 ft horizontally and then rises 135 ft at an angle of 30.0° above the horizontal. It next travels 135 ft at an angle of 40.0° downward. What is its displacement from its starting point?

3. A projectile is fired such that the maximum height it reaches is three times the distance it travels before it lands. Find the angle of projection.

4. A bullet is fired from a gun on the surface of the earth(radius 6340 km) at velocity v. Find v such that the bullet will enter a stable orbit around the moon at its inital height.

Intermediate problems:

1. A projectile is launched at an angle θ to the horizontal. It rises to a height h and lands a distance d away. Find the ratio h/r in terms of θ.

2. For the vector $\vec{R} = 2\vec{i} + \vec{j} + 3\vec{k}$, find the magnitude of $\vec{R}$, and the angles between $\vec{R}$ and the x, y, and z axes.

3. A dive-bomber has a velocity of $280\frac{\text{m}}{\text{s}}$ at an angle θ below the horizontal. It releases a bomb at an altitude of 2.15 km, which initially has the same velocity as the aircraft. The distance from the point of release (not just horizontal distance) is 4km

Advanced problems:

1. The speed of a projectile at its greatest height is $\sqrt{\frac{6}{7}}$ of its speed when it is at half of its greatest height. Find the angle of projection.

2. The speed of a projectile at its greatest height h is m times its speed when it is at a height nh, where $n < 1$. Find the angle of projection in terms of m and n.

3. A ski jumper jumps off a ramp at angle θ to land on a hill that slopes downward and makes an angle ψ with the horizontal. Find θ such that the ski jumper's distance is maximized.

4. A ball is kicked off a hemispherical rock of radius R with horizontal velocity v. Assume no friction between the rock and the ball. Find the distance away from the center of the rock the ball lands in terms of R and v.