1. A particle $P$ of constant mass $m$ slides without rolling down an inclined plane of angle $\alpha$ that has a constant coefficient of friction $\mu$, see Fig. 1.

![Figure 1:](image)

If the particle starts from rest at the top of the incline (at point $A$) find:

(a) the acceleration,
(b) the velocity,
(c) the distance traveled after time $t$.

2. Refer to Fig. 2. An inclined plane makes an angle $\alpha$ with the horizontal.
A projectile is launched from the bottom of the plane (point $O$) with speed $v_0$ in a direction making an angle $\beta$ with the horizontal. Prove that the range $R$ up the incline is given by:

$$R = \frac{2v_0^2 \sin(\beta - \alpha) \cos \beta}{g \cos^2 \alpha}.$$

3. An object slides on a surface along the horizontal straight line $OA$, see Fig. 3.

![Figure 3](image)

We assume that $x = 0$ and $v = v_0$ at $t = 0$. Suppose that the object comes to rest after traveling a distance $x_0$. Show that the coefficient of friction is:

$$\frac{v_0^2}{2g x_0}.$$

4. In the projectile problem discussed in lectures, the expression for the vertical displacement of the particle as a function of time is given by:

$$z(t) = (v_0 \sin \alpha) t - \frac{g}{2} t^2.$$

Clearly, for $t$ sufficiently large, $z(t)$ can be negative. Does this pose any problems?
5. Consider a projectile problem where, at a distance $d$ from the launch point of the projectile, the horizontal boundary suddenly "drops" to a distance $H$ below zero, see Fig. 4.

![Figure 4](image)

Figure 4:

Compute the time that it takes the projectile to reach the vertical distance $H$ below the launch point.

6. Consider a projectile problem where, at a distance $d$ from the launch point of the projectile, a wall is placed of height $H$, see Fig. 4 (the wall is parallel to the $x-z$ plane).

![Figure 5](image)

Figure 5:

(a) Compute the time that it takes the projectile to hit the wall.
(b) Show that a necessary condition for a particle to hit the wall at a height $T > 0$ is:

$$d < \frac{2v_0^2 \sin \alpha \cos \alpha}{g}.$$

(c) Now suppose $\alpha = 45^0$, $v_0 = 100\text{m/s}$, and $g = 9.8\text{m/s}^2$. With these parameters fixed, what value of $d$ must we take in order to hit the wall at a height of $10\text{m}$?