Problem 1

A particle of mass \( m \) slides without friction on a smooth inclined plane \( M \) which, itself, is free to slide without friction on a smooth horizontal surface.

(a) Select a complete and independent set of generalized coordinate(s).

(b) Derive the governing equation(s) of motion using momentum principles.
Problem 2

A disk or radius $r$ and mass $m$ rolls without slipping on the surface of a stationary half-cylinder of radius $R$, as shown below. Because of the rolling constraint, this is a one-degree-of-freedom system, and the angle $\theta$ is a convenient generalized coordinate.

(a) Express the angular velocity of the disk in terms of $\dot{\theta}$.

(b) Calculate the kinetic energy of the disk.
Problem 3

Falling Rod. A rigid rod AB has length $L$, mass $m$, and centroidal moment of inertia $I_C = mL^2/12$. The rod is constrained to remain in the plane of the sketch and is completely located by giving the coordinates $x$ and $y$ of the mass center C, with respect to an inertial reference system, and the angle $\theta$ that the rod makes with the vertical. The rod is placed with the end B in contact with the floor and the angle $\theta$ equal to 30 degrees and released from rest. Assume that, as the rod falls under the influence of gravity, the end B always remains in contact with the floor, and that there is no frictional force between the floor and the rod at B.

(a) The generalized coordinates $x$, $y$, and $\theta$ are complete but not independent under the constraints described below. Select a set of complete and independent generalized coordinates to describe the location of the falling rod.

(b) Derive the equation(s) of motion. It is not necessary to solve the equation(s).

(c) Determine the angular acceleration $\ddot{\theta}$ of the rod immediately after it is released from rest.

(d) Determine the force between the floor and the rod at B, immediately after the rod is released from rest.

![Figure 1: Rod falls under the influence of gravity](image-url)