भारतीय प्रौद्योगिकी संस्थान पटना

INDIAN INSTITUTE OF TECHNOLOGY PATNA

PH101 (Physics-I) **Tutorial-V (August 25, 2014)**

[Variable Masses and Conservation Laws]*

1. A heavy uniform rope of mass M and length l is held symmetrically over a thin smooth horizontal peg. On a slight disturbance, the rope begins to slide off the peg. Find the speed of the rope when it finally leaves the peg.

2. A uniform heavy rope of mass M and length l is held at rest with its two ends close together such that the rope hanging symmetrically (neglect thickness of the rope).
(a) If one end is then released, find the velocity of the free end when it has descended by a distance x.
(b) Show that the acceleration of the free end always exceeds g.
(c) Obtain the displacement of the free end when the acceleration has risen to 5g.

3. A heavy uniform rope of mass M and length $4l$ has one end connected to a fixed point on a smooth horizontal table by light elastic spring of natural length l and modulus $Mg/2$, while the other end hangs down over the edge of the table. When the spring has its natural length, the free end of the rope hangs a distance l vertically below the level of the table top. The system is released from rest in this position. Show that the free end of the rope executes simple harmonic motion, and find its period and amplitude (Note: ignore thickness of the rope).

4. In free space, a rocket of initial mass M, of which $M - m_R$ is fuel, burns its fuel at a constant rate k and ejects the exhaust gases with constant speed u. The rocket starts from rest and moves through a medium that exerts the resistance force ϵkv, where v is the forward velocity of the rocket, and ϵ is a small positive constant. Find the maximum speed v_{max} achieved by the rocket. For small ϵ obtain the leading contributions to v_{max}.

5. You are riding on a sled that is given an initial push and slides across frictionless ice. Snow is falling vertically (in the frame of the ice) on the sled. Assume that the sled travels in tracks that constrain it to move in a straight line. Which of the following three strategies causes the sled to move the fastest? The slowest?
(A) You sweep the snow off the sled so that it leaves the sled in the direction perpendicular to the sleds tracks, as seen by you in the frame of the sled.
(B) You sweep the snow off the sled so that it leaves the sled in the direction perpendicular to the sleds tracks, as seen by someone in the frame of the ice.
(C) You do nothing.

*Note: Please follow the strategies for "Problem Solving" explained in the class.