19-1-15 #4

Refer to Kleppner, Special Indian edition

Date: 22nd January, 2015 **Problem Set: 4** **Phy102**

Newton's laws and Forces of nature: (Rough Sketches at the back)

1 A 45^0 wedge is pushed along a table with a constant acceleration A. A block of mass m slides without friction on the wedge. Find its acceleration. (Gravity is directed down) (Kleppner 2.16)

2 The system as shown in the figure (Kleppner 2.15) uses massless pulleys and rope. The coefficient of friction between the masses and horizontal surfaces is μ. Assume M_1 and M_2 are sliding. Gravity is directed downwards. Find the tension in the rope.

3 A uniform cylinder of radius R and mass m is kept vertically against a dry surface. It is to be rotated vertically by applying a torque τ. If the coefficient of friction between the surface and the cylinder is μ, calculate the torque when the cylinder is about to rotate. (One may assume that the normal reaction is uniformly distributed)

4 A particle of mass m moving along a straight line is acted upon by a retarding force (one always directed against the motion), $F = be^{\alpha v}$, where b and α are constants and V is the velocity. At $t = 0$, it is moving with a velocity V_0. Find the velocity at a later time.

5 A particle of mass m is projected from the origin vertically upward with an initial velocity V_0 in a medium, which offers a resistance force of the form mk^2v^2 opposing the motion. Assume gravity is constant and directed downward. The particle reaches a maximum height and returns to the origin with a speed V_1. Show that

$V_1^2 = \frac{V_0^2 V_t^2}{V_0^2 + V_t^2}$, where V_t denotes the terminal velocity in this medium. (Note that when V_0 increases, $V_1 \to V_t$)

Additional Problems

1 A mass m is connected to a vertical revolving axle by two strings of length l, each making an angle 45^0 with the axle. Both the axle and the mass are revolving with an angular velocity ω. Gravity is downward. Find the tension in the upper string and the lower string.

2 Kleppner Problem 2.24 (It is on a device called capstan and uses the principle of rough pulley)

3 The density of a thin rod of length l varies with a distance x from one end as $\rho(x) = \rho_0 \frac{x^2}{l^2}$. Show that the position of the center of mass is at $x = \frac{3l}{4}$.

Reading material: Kleppner Examples 3.3-3.8