2002

EXAM III Physics 218

Name.....Section Number.....

USEFUL INFORMATION

$$If \quad f(x) = kx^n \qquad \frac{df}{dx} = nkx^{n-1}$$

$$If \quad f(x) = kx^n \qquad \int_A^B f(x)dx = \frac{1}{n+1}k(B^{n+1} - A^{n+1})$$

$$\int_{\vec{r}_1}^{\vec{r}_2} \vec{F}_{tot} \cdot d\vec{r} = \frac{1}{2}mv^2(\vec{r}_2) - \frac{1}{2}mv^2(\vec{r}_1)$$

If $\vec{F}$ is conservative:

$$\int_{\vec{r}_1}^{\vec{r}_2} \vec{F} \cdot d\vec{r} = -[U(\vec{r}_2) - U(\vec{r}_1)]$$

and

$$F_x = -\frac{\partial U}{\partial x} \qquad F_y = -\frac{\partial U}{\partial y}$$

$$\vec{L} = \vec{r} \times \vec{p} \qquad \vec{\tau} = \vec{r} \times \vec{F} \qquad I = \sum m_i r_i^2$$

DO NOT WASTE TIME DOING ARITHMETIC

1.

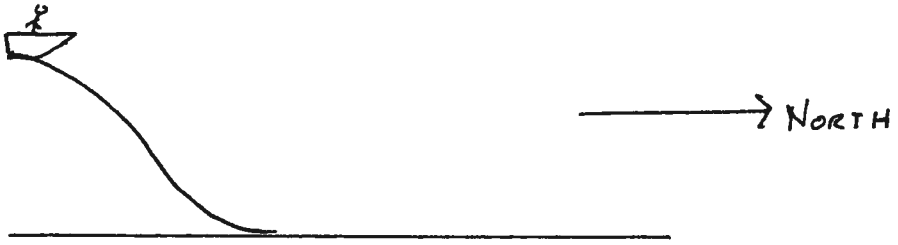
2.

3.

4.

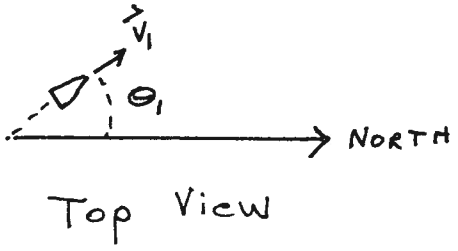
1. (25 points)Derive the expressions for the $\vec{i}_r$ and $\vec{i}_\theta$ components of the velocity and acceleration.

2. (25 points)A man of mass m_1 sits on a sled, mass m_2 on the top of a frictionless hill of height H. The sled starts down the hill with an initial velocity v_0 directed towards the North.

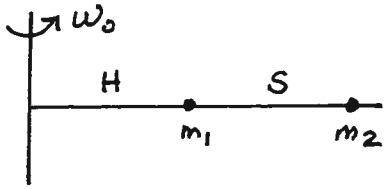


a. What is the man's velocity at the bottom of the hill? Call it $\vec{v}_B$.

b. At the bottom of the hill the surface is solid ice so that there is no friction. The man jumps off the sled onto another sled, mass m_3 which is at rest. The empty sled goes off at an angle θ_1 with velocity of magnitude v_1. Obtain the necessary equations to determine the position of the man T seconds after he jumps from one sled to the other? DO NOT SOLVE THE EQUATIONS!



3. (25 points)A massless rod can rotate without friction about a vertical axle. A small mass m_1 is fixed to the rod a distance H from the axle. A second small mass m_2 is initially a distance S from the first mass, as shown.



The rod and the masses are set into motion rotating about the axle with angular velocity ω_0. At $t = 0$ m_2 begins to move towards m_1 so that the distance between them is $S - ct^2$ where c is a known constant.

a. What will be the angular velocity of the rod as a function of time while m_2 is moving towards m_1?

b. What is the force that the rod exerts on m_2 while it is moving?

c. If the rod were not massless but instead had a moment of inertia I_{rod} about the axle, what would be the angular velocity of the rod as a function of time while m_2 is moving towards m_1?

4. (25 points)An electron with mass m and charge of magnitude q_1 is attracted to a proton, which is fixed at the origin, by a force of magnitude

$$F = \gamma \frac{q_1 q_2}{r^2}$$

where γ is a known constant, q_2 is the charge of the proton and r is the distance of the electron from the origin.

a. If the electron moves in the x, y plane in a circle of radius R, what is its angular momentum about the origin?

b. If instead of moving in a circle the electron's position was given by $r(t) = r(0) + c_1 t$, $\theta(t) = \theta(0) + c_2 t$ where $r(0)$, c_1, $\theta(0)$, and c_2 are known, what would be the kinetic energy of the electron?

c. Calculate the work done by the force exerted by the proton if the electron moves from the point $r = R, \theta = 0$ to the point $r = 2R, \theta = \frac{\pi}{4}$.