Physics 200a Sample Midterm Questions
Formulas and figures at the end
I expect this assortment of problems to take about 90 minutes

1. A block of mass m starts with negligible speed from the top of an inclined plane of angle α and coefficient of friction μ_k, as shown in Fig. 1. Using Newton's laws find the speed at the bottom and show that it is in agreement with the law of conservation of energy. **15**

2. A small mass m sits on top of a big mass M as shown in Fig. 2. The coefficient of static friction between them is μ_s. The lower mass is connected to a spring of force constant k. What is the maximum amount A by which the spring can be stretched so that the upper mass does not slip off the top as the lower mass begins to move? Argue that if this condition is satisfied the upper mass will never slip during subsequent motion. **15**

3. A trolley of mass m is released by a compressed spring of force constant k. By how much should the spring be compressed if the mass is to safely make the loop of radius R shown in Fig. 3? How far will it slide down the rough surface that follows, where the coefficient of friction is μ_k? **20**

4. A satellite is in an elliptical orbit around the earth with altitudes ranging from 230 to 890 km. At the highest point it has a speed of 7.23 km/s. What will be the speed at the lowest point? ($G = 6.67 \cdot 10^{-11} N \cdot m^2/kg^2, \quad M_{earth} = 5.97 \cdot 10^{24} kg, \quad R_E = 6.37 \cdot 10^6 m$ **10**

5. Find the work done by the force

$$\mathbf{F} = \mathbf{i}x^2y^2 + \mathbf{j}yx$$

on a path $y = x^2$ between $(0,0)$ and $(1,1)$. **15**

6. A crane holds up a mass 5000kg from the end of a boom of length 10m (assumed massless and at an angle of 60°). Find T, the tension on the cable supporting the boom at an angle of 30°. (Fig. 4) **10**

7. A solid cylinder of mass M and radius R rolls down an incline plane of angle θ without slipping. Find its angular and linear acceleration down the slope. (Fig. 5) **10**

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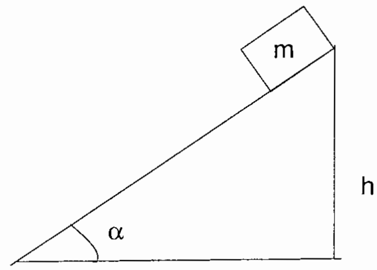

FIG. 1. The mass is given a slight tap to get it going downhill.

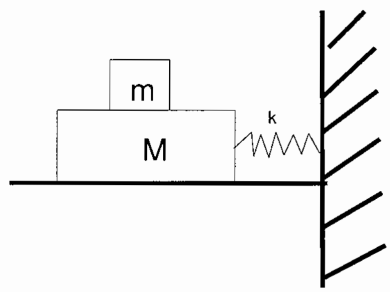

FIG. 2. The coefficient of static friction between the two masses is μ_s.

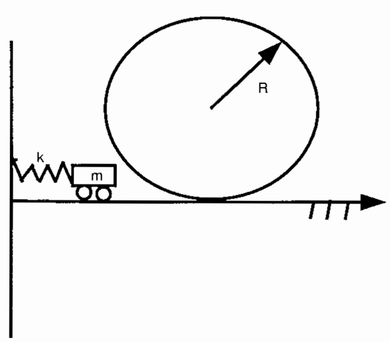

FIG. 3. The compressed spring ejects the trolley, which goes around the loop. After the loop it encounters a stretch (shown by hatched lines) with frictional coefficient μ_k.

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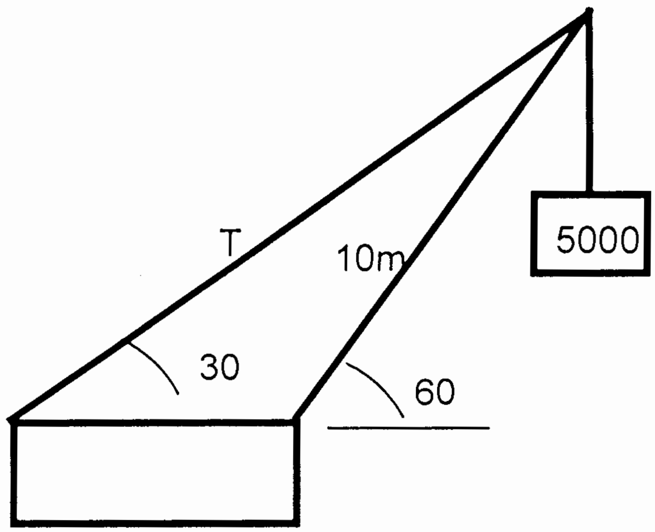
FIG 4



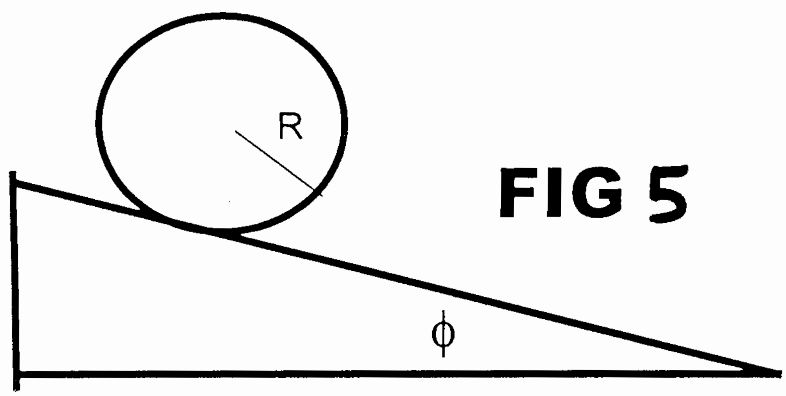


FIG 5

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Data Sheet

$$\mathbf{r} = \mathbf{r}_0 + \mathbf{v}_0 t + \frac{1}{2}\mathbf{a}t^2$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$F = \frac{GM_1M_2}{r^2}$$

$$G = 6.6 \cdot 10^{-11} N \cdot m^2/kg^2$$

$$E = K + U$$

$$U = mgh \text{ near earth,}$$

$$U = -\frac{GM_1M_2}{r}$$

$$U = \frac{1}{2}kx^2$$

$$M_E = 6 \cdot 10^{24} kg$$

$$E_2 - E_1 = W_{friction} \qquad \text{Law of Conservation of Energy}$$

$$W = \int_1^2 \mathbf{F} \cdot \mathbf{dr} \qquad (= U(1) - U(2) \;\; \text{For conservative forces})$$

$$m_1v_1 + m_2v_2 = m_1v_1^{'} + m_2v_2^{'} \quad \text{momentum conservation}$$

$$\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 = \frac{1}{2}m_1v_1^{'2} + \frac{1}{2}m_2v_{'2}^2 \quad \text{conservation of kinetic energfy}$$

$$\theta = \theta_0 + \omega_o t + \frac{1}{2}\alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

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$$\tau = I\alpha \qquad \tau = Fr\sin\theta$$

$$\Delta W = \tau\delta\theta$$

$$I = \sum_i m_i r_i^2$$

$$I_{CM} = \frac{MR^2}{2} \text{ disk or cylinder} \qquad \frac{2MR^2}{5} \text{solid sphere} \qquad \frac{ML^2}{12} \text{ rod}$$

$$W = \int_{\mathbf{r}_1}^{\mathbf{r}_2} \mathbf{F}\cdot d\mathbf{r} \quad (= U(1) - U(2) \text{ if conservative}$$

$$L = I\omega \qquad K = \frac{1}{2}I\omega^2$$

$$I = I_{CM} + Md^2 \quad \text{Parallel axis theorem for an axis a distance } d \text{ from CM}$$

$$E = K + V \quad V = (1/2)kx^2 \quad V = mgh \text{ near earth}$$

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