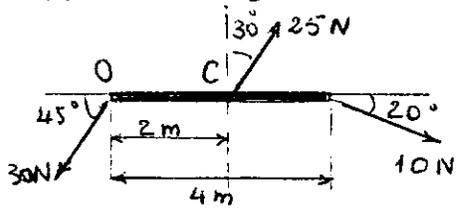
AUB | **Physics 101** | **August 25, 1997**
Physics Department | **Final Exam** | **Time: 2 hours**
Name:_____
I.D. #:_____

1) ***20 marks***

Calculate the net torque (magnitude and direction) on the beam shown in the figure, about (a) an axis through O, perpendicular to the figure and (b) an axis through C perpendicular to the figure.



2) ***15marks***

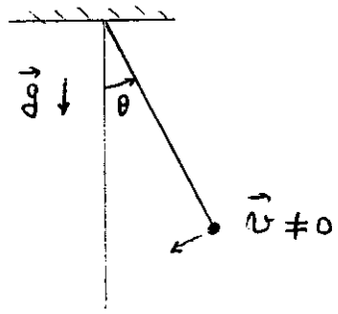
A particle moves in the xy plane with an x component of acceleration only, given by $a_x = 4 m/s^2$ ($a_y = 0$). The particle starts from the origin at t = 0 with an initial velocity having an x component of 20 m/s and a y component of -15 m/s.

a) Determine the components of velocity as a function of time and the total velocity vector $\vec{v}$ at any time. Can $\vec{v}$ be zero?
b) Calculate the velocity and speed of the particle at t = 5 s.
c) Determine the x and y coordinates at any time t and the displacement vector $\vec{r}$ at this time.

3) ***15 marks***

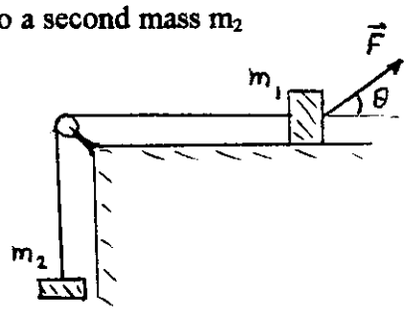
A ball tied to the end of a string 0.5 m in length swings in a vertical circle under the influence of gravity. When the string makes an angle $\theta = 20°$ with the vertical, the ball has a speed of 1.5 m/s.

a) Find the radial component of acceleration at this instant.
b) Find the tangential component of acceleration at this instant.
c) Find the magnitude and direction of the total acceleration at this instant.



4) ***20 marks***

A block of mass m_1 on a rough, horizontal surface, is connected to a second mass m_2 by a light cord over a light frictionless pulley as in the figure. A force of magnitude F is applied to mass m_1 as shown. The coefficient of kinetic friction between m_1 and the surface is μ. Determine the acceleration of the masses and the tension in the cord.

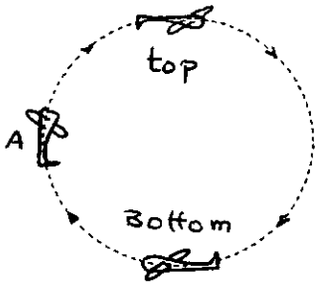


5) ***15 marks***

A pilot of mass m in a jet aircraft executes a "loop-the-loop" maneuver as illustrated in the figure. In this flying pattern, the aircraft moves in a vertical circle of radius 2.70 km at a constant speed of 225 m/s . Determine the force of the seat on the pilot at

a) the bottom of the loop and b) the top of the loop.

Express the answers in terms of the weight of the pilot : mg .



6) ***15 marks***

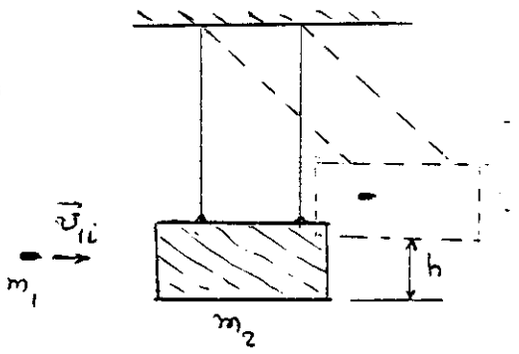
A 65-kg athlete runs a distance of 600 m up a mountain inclined at 20° to the horizontal. He performs this feat in 80 s. Assuming that air resistance is negligible **a)** how much work does he perform and **b)** What is his power output during the run? (Assume that he runs at a constant speed).

7) ***20 marks***

Plot the potential energy $U(x) = U_o\,(x + e^{-2x})$ of a particle moving in along the x-axis for $-1 \leq x \leq +1$. Find the equilibrium position of this particle and specify its nature.
If U (x) is - U'(x) and U'(x) is the potential energy of the particle, what are your new conclusions?

8) ***15 marks***

The bullet of mass $m_1 = 0.05$ g is fired into a large block of wood ($m_2 = 2$ kg) suspended from some light wires. The bullet is stopped by the block, and the entire system swings through a height h = 20 cm. The collision is perfectly inelastic, find the initial velocity v_{1i} of the bullet.



9) ***15 marks***

A rocket moving in free space has a speed of 3×10^3 m/s. Its engine are turned on, and fuel is ejected on a direction opposite the rocket's motion.

a) What is the speed of the rocket once its mass is reduced to one half its mass before ignition?

b) What is the thrust on the rocket if it burns fuel at the rate of 50 kg/s?

10) ***15 marks***

The turntable of a record player rotates initially at a rate of 33 revolutions/min and takes 20 s to come to rest.

a) What is the angular acceleration of the turntable, assuming the acceleration is uniform ?

b) How many rotations does the turntable make before coming to rest?

c) If the radius of the turntable is 14 cm, what are the magnitude of the radial and tangential components of the linear acceleration of a point on the rim at t = 0 ?

11) ***20 marks***

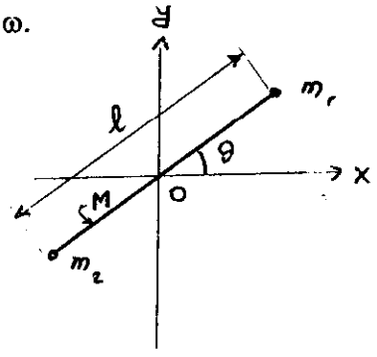
A rigid rod of mass M and length ℓ rotates in a vertical plane about a frictionless pivot through its center. Particles of masses m_1 and m_2 are attached at the ends of the rod.

a) Determine the angular momentum when the angular velocity is ω.

b) Determine the angular acceleration of the system when the rod makes an angle θ with the horizontal.

c) If $m_1 = m_2$ what is the value of the angular acceleration.

d) If $m_1 > m_2$, at what value of θ is ω a maximum .



12) ***15 marks***

A string is wound around a uniform disk of radius R and mass M. The disk is released from rest with the string vertical and its top end tied to a fixed support. As the disk descends, show that

a) The tension in the string is one third the weight of the disk,

b) The acceleration of the center of mass is 2g/3,

and c) the velocity of the center of mass is $(4\ gh/3)^{1/2}$.