Physics 170 Final Examination 12/19/95

Name (Printed):

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Instructions:
This is an "open-textbook, open-note" examination. You may use a calculator, your own notes, Kleppner and Kolenkow, Tipler, and any materials handed out in class. You may not use any other textbooks or any other materials prepared by a third party. Show all of your work neatly in the space provided, using reverse side of page if necessary. If you change your mind about an answer, make sure that the incorrect answer is crossed out and the correct one is clearly indicated. The test consists of five problems, all weighted equally but not necessarily equally difficult.

#1 (40 Points) A block of mass \( m \) sits on a wedge with angle \( \theta \), as shown below. The static coefficient of friction is \( \mu_s \). An external force causes the wedge to slide back and forth in the horizontal direction; its motion is described by \( x(t) = A \cos(\omega t) \). As usual, gravity points downward.

Say as much as you can about the motion of the block. In particular, for what combinations of \( A, \omega, m, \theta, \mu_s \), and \( g \) will the block stick to the wedge and move back and forth with it without sliding, for what combinations will it slide on the wedge but not lose contact, and for what combinations will it fly completely off the wedge losing contact with the surface?

Click here for solution.

#2 (40 Points): Three identical disks are prepared, each with mass \( M \), radius \( R \), and thickness \( d \). Disk 'A' is not altered in any way. Disk 'B' has four small circular holes of radius \( r \ll R \) symmetrically drilled a distance \( R/4 \) from the center of the disk. Disk 'C' has four small holes of radius \( r \) symmetrically drilled a distance \( 3R/4 \) from the center of the disk. The three disks are allowed to roll without slipping down a ramp.
In what order will they reach the bottom? Provide a detailed analytical justification for your answer (no credit if you give the right answer without any justification, since you have one chance in 6 of doing this by chance!).

Click here for solution.

#3 (40 Points): A particle of reduced mass \( \mu \) moves under the influence of a repulsive central force \( F = e/r^3 \). At a large distance from the origin the particle has velocity \( v_0 \) and an impact parameter \( b \).

What will be the distance of closest approach to the origin?

Click here for solution.

#4 (40 Points): A block of mass \( M \) slides without friction and has a loop-the-loop apparatus of height \( h \) mounted on it, as shown below.

The loop is originally at rest. A second block with mass \( m \) approaches from the left with initial speed \( v_0 \) and goes around the loop. Assume that the block on which the loop is mounted slides smoothly and does not tip over or otherwise misbehave. What is the minimum speed \( v_0 \) such that the block will go all the way around without losing contact with the loop? (Partial credit will be given if you set up the initial equations correctly but do not carry out all the algebra; in this case you should explain as clearly as possible what assumptions or physical principles you have used).

Click here for solution.

#5 (40 Points): A child's merry-go-round is constructed in the shape of a solid disk with radius \( R \) and mass \( M \). It is mounted on a frictionless pivot and has initial angular velocity \( \omega_0 \). A light snow starts to fall, coating the surface of the disk uniformly. Mass is added at a constant rate \( \frac{dm}{dt} = \alpha \). Calculate the angular speed of the merry-go-round, \( \omega(t) \), as a function of \( t \), \( M \), \( R \), \( \alpha \), and \( \omega_0 \).

Click here for solution.