Physics 3210, Spring 2018 Name:

Exam #2 Signature:

UID:

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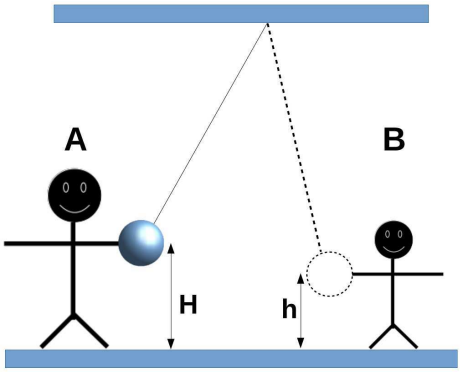
Please read the following before continuing:

- Show all work in answering the following questions. Partial credit may be given for problems involving calculations.
- Be sure that your final answer is clearly indicated, for example by drawing a box around it.
- Be sure that your cellphone is turned off.
- Your signature above indicates that you have neither given nor received unauthorized assistance on any part of this exam.
- Thanks, and good luck!

1. (8 pts) Alice (A) is holding a pendulum bob of mass $m$ at a height $H$ above the ground (solid line). At time $t = t_o$, she releases the bob from rest, and it swings until caught and brought to rest by Brad (B) at a lesser height $h$ at time $t = t_1$ (dashed line). The following questions pertain to the work done on the bob between $t_0$ and $t_1$ only. Be sure to give both magnitudes and signs in your answers.



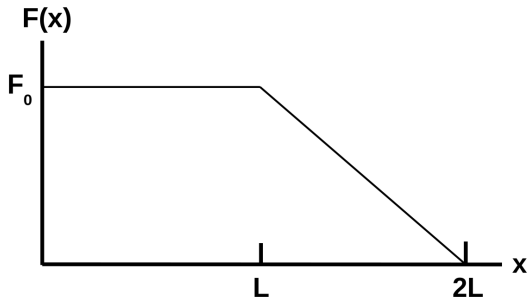

   (a) (2) What work did Alice do on the bob? _____

   (b) (2) What work did gravity do on the bob? _____

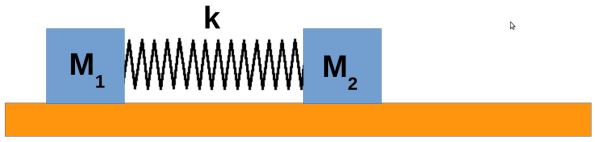
   (c) (2) What work did tension do on the bob? _____

   (d) (2) What work did Brad do on the bob? _____

2. (8 pts) The graph below shows the force applied in the positive $x$-direction, to an object of mass $m$ as a function of position $x$. The object starts at rest. The force is constant $F_0$ until the object reaches $x = L$, then it decreases linearly to zero until the object reaches $x = 2L$. What is the speed of the object at $x = 2L$?



3. (14 pts) Two blocks with mass $M_1$ and $M_2$ are connected by a spring with spring constant $k$ and are sliding on a frictionless horizontal surface. Their positions are given by coordinates $x_1$ and $x_2$ respectively, defined such that when $x_1 = x_2$ the spring is unstretched.

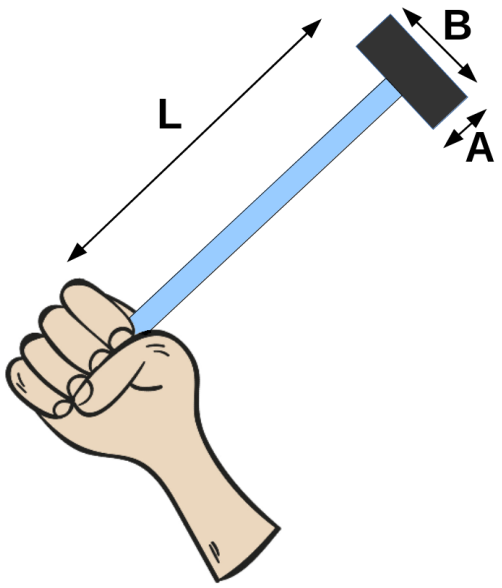



(a) (4) Write down the Lagrangian for this system.

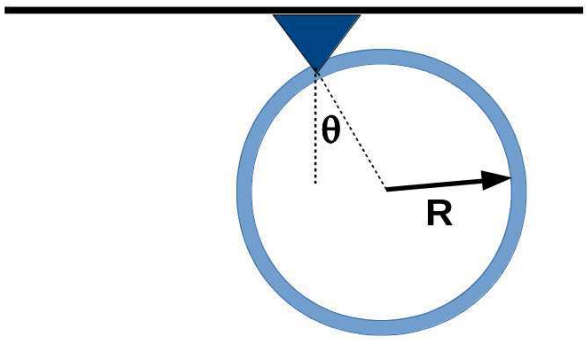
(b) (4) Use the Lagrangian to determine two coupled equations of motion for the two blocks.

(c) (6) Show that if $M_1$ is moving with constant velocity then $M_2$ must also be moving with constant velocity.

4. (6 pts) A carpenter swings a hammer to strike a nail. The hammer consists of a handle (thin rod) of mass $m$ and length $L$, and a rectangular head of width $A$, length $B$ and mass $M$. Calculate the moment of inertia of the hammer, about the end of the hammer in the carpenter's hand.



5. (16 pts) A pendulum consists of a thin ring of mass $M$ and radius $R$, attached to a pivot at a point on its rim.

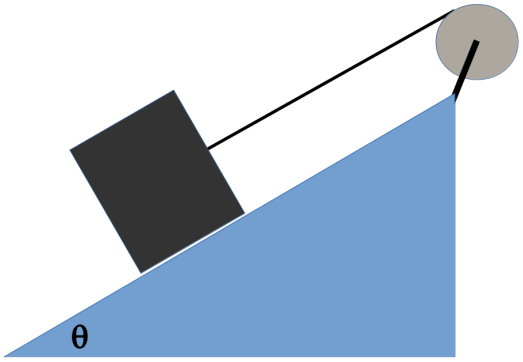



(a) (8) Compute the period of the pendulum, in the limit of small oscillations.

*Problem continued on the following page.*

(b) (8) Write a particular solution for the pendulum's motion in the case that it is initially hanging vertically and has initial angular velocity $\omega_0$ clockwise.

6. (16 pts) A block of mass $m$ is held by a long massless string on a frictionless inclined plane inclined at an angle $\theta$ to the horizontal. The string is wound on a uniform solid cylindrical drum of mass $M$ and radius $R$ as shown in the figure. The drum is given an initial angular speed $\omega$ such that the block starts moving up the plane.

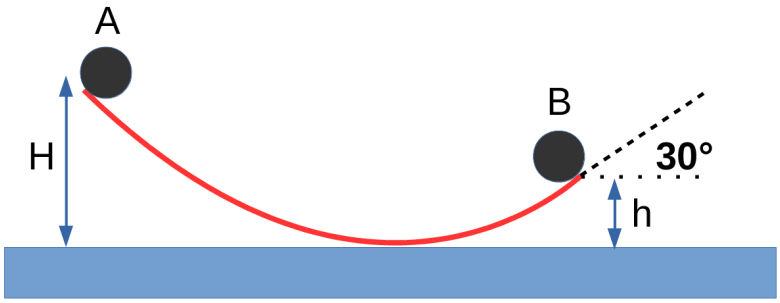



(a) (8) Draw complete *Free Body Diagrams* for the block and drum. Be sure to indicate *all* forces acting on each.

*Problem continued on the following page.*

(b) (8) Find the tension in the string during the motion.

7. (16 pts) A solid disk of radius $R$ and mass $m$ is released from rest at Point A on a curved ramp, at a height $H$ above the bottom. The disk rolls without slipping to B, at which point it leaves the ramp at an angle of 30° with respect to horizontal.

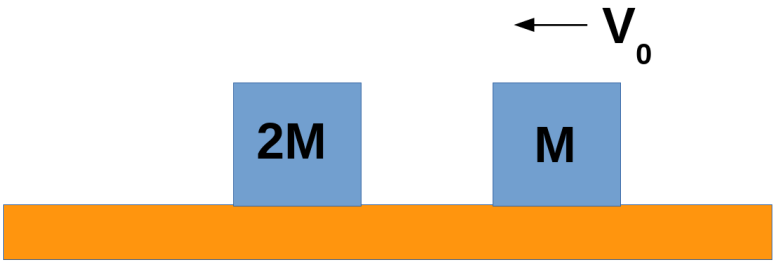


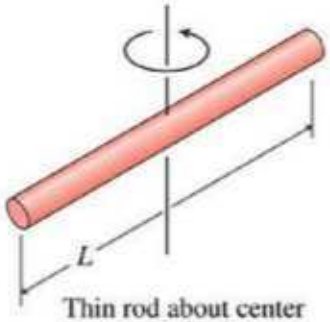

(a) (10) In terms of $m$, $g$, $R$, $H$ and $h$, what is the *angular* speed of the disk at point $B$?

*Problem continued on the following page.*

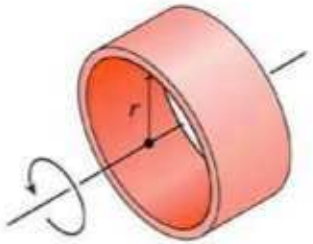
(b) (6) What is the horizontal distance the disk will travel before reaching its maximum height?

8. (16 pts) Two blocks, as shown in the figure, are on a frictionless surface. A block with mass $M$ slides to the left with speed $v_0$, until it collides elastically with a block of mass $2M$ which is initially at rest. Calculate the final velocities (magnitude and direction) of the two blocks, $v_1$ and $v_2$.



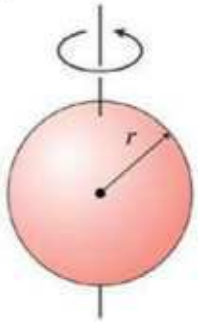



Thin rod about center
$I = \frac{1}{12}ML^2$

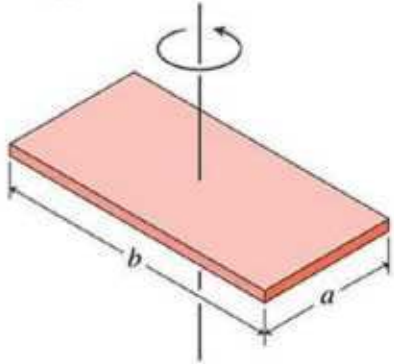


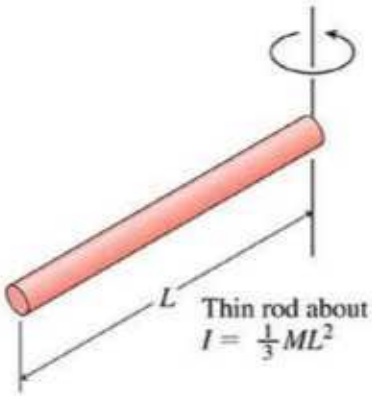

Thin ring or hollow cylinder about its axis
$I = MR^2$

Solid sphere about diameter
$I = \frac{2}{5}MR^2$

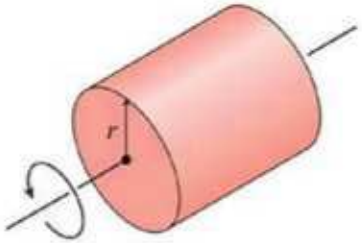



Flat plate about perpendicular axis
$I = \frac{1}{12}M(a^2 + b^2)$



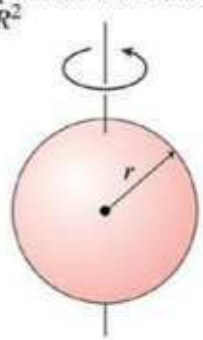




Thin rod about end
$I = \frac{1}{3}ML^2$




Disk or solid cylinder about its axis
$I = \frac{1}{2}MR^2$

Hollow spherical shell about diameter
$I = \frac{2}{3}MR^2$




Flat plate about central axis
$I = \frac{1}{12}Ma^2$