INSTRUCTIONS: Write your NAME and your SECTION (01: 8:30/Eskildsen, 02: 3:00/Tang) on the front of the blue exam booklet. The exam is closed book, and in addition to the equation compendium only pens/pencils and a calculator (no stored equations or programs and no graphing) may be used.

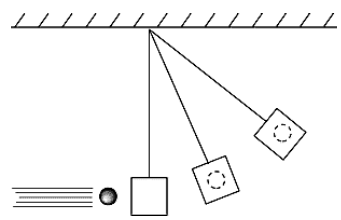
The distributed compendium must be returned at the end of the exam. Please do not write in it.

For problems II-V you must write the complete solution in your blue book. No credit (full or partial) will be given for an answer without supporting work. Draw a diagram when possible, circle or box your final answers, and cross out parts which you do not want us to consider.

I. Multiple Choice Questions (4 points each)

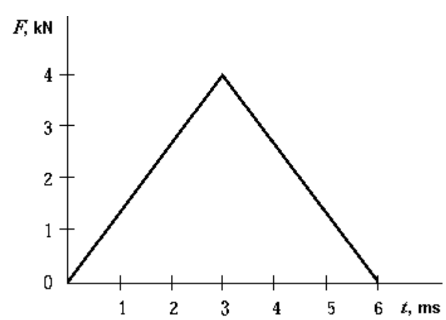
Read each question carefully. Write the *single* correct answer in the grid on the first page inside your blue book. No explanation is required, and no partial credit will be given.

MC1. The figure below shows a ballistic pendulum in three states. The collision between the ball and pendulum can be regarded as instantaneous ($\Delta t = 0$). The system (considered to be the ball and pendulum) will move in such a way that



A) The kinetic energy is conserved during the collision.
B) The linear momentum is conserved after the collision.
C) The linear momentum changes during the collision.
D) The total mechanic energy is conserved during the collision.
E) The total mechanic energy is conserved after the collision.

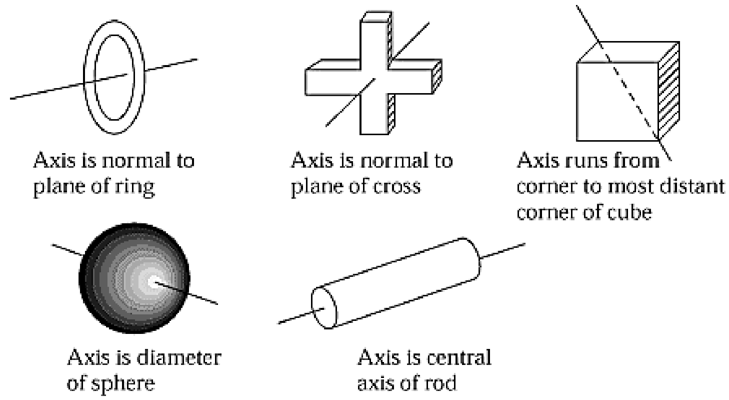
MC2. A 4.0 kg block, initially at rest, experiences a force that varies with time as shown in the figure. When t = 6.0 ms, the speed of the block is



A) 3.0 m/s
B) 5.0 m/s
C) 6.0 m/s
D) 12 m/s
E) 6.0 km/s

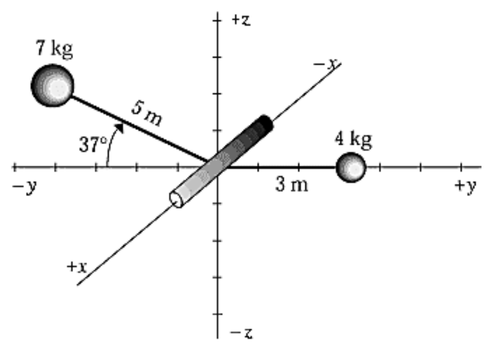
MC3. Assume that all the objects in the figure have equal mass and physical dimension (ie. diameter, height/width, diagonal). The moment of inertia about the indicated axis is largest for the

A) ring
B) cross
C) sphere
D) cub
E) rod



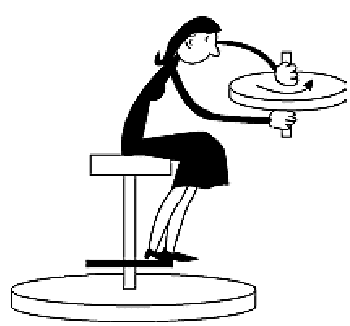
MC4. A 7.0 kg mass and a 4.0 kg mass are connected to a spindle by rigid rods. The spindle is free to turn about the *x*-axis as shown. Assume the mass of the rods and the spindle to be negligible. The magnitude of the resultant torque on the spindle is approximately

A) 82.2 Nm
B) 156 Nm
C) 226 Nm
D) 392 Nm
E) 461 Nm



MC5. A woman sits on a stool that can rotate without friction about its vertical axis. She is handed a spinning bicycle wheel that has angular momentum $\vec{L}_0$ and she turns it over (that is, through 180º). She thereby acquires an angular momentum of magnitude:

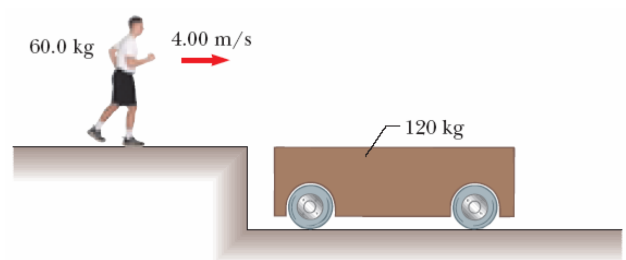
A) 0
B) ½ $\vec{L}_0$
C) $\vec{L}_0$
D) $2\vec{L}_0$
E) $4\vec{L}_0$



Problems (20 points each)

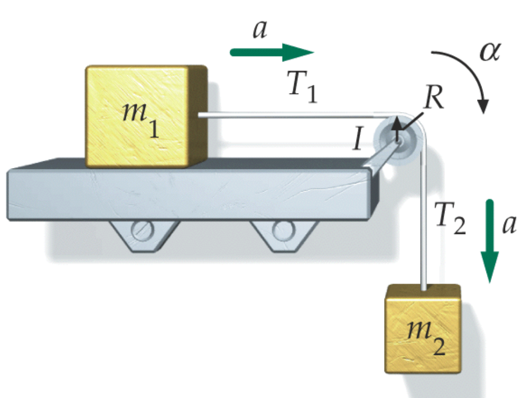
II. A 60 kg person running at an initial speed of 4.0 m/s jumps onto a 120 kg cart initially at rest (see figure). The person slides on the cart's top surface and finally comes to rest relative to the cart. The coefficient of kinetic friction between the person and the cart is 0.4. Friction between the cart and ground can be ignored.

a) Find the final velocity of the person and cart relative to the ground. (5 pts)
b) Find the change in momentum of the person and of the cart. (5 pts)
c) Find the friction force acting on the person while he is sliding across the top surface of the cart. (2 pts)
d) How long does the friction force act on the person? (3 pts)
e) Find the mechanic energy loss via friction. (5 pts)



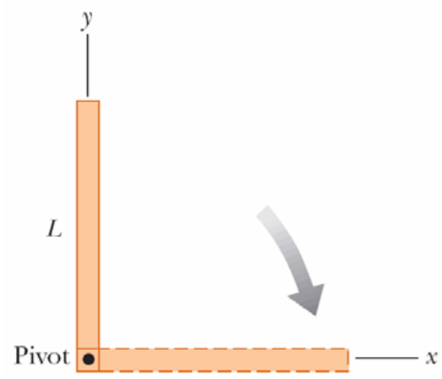
III. Two blocks are connected by a string that passes over a pulley of radius $R = 0.1$ m and momentum of inertia $I = 0.01$ kg·m^2. The block of mass $m_1 = 1.0$ kg slides on a frictionless, horizontal surface; the block of mass $m_2 = 1.0$ kg is suspended from the string (see figure below).

a) Find the acceleration of the blocks and the angular acceleration of the pulley. (10 pts)
b) Find the tensions T_1 and T_2. (10 pts)



IV. A long uniform rod of length L = 1.0 m and mass M = 1.0 kg is pivoted about a horizontal, frictionless pin through one end. The rod is released from rest in a vertical position as shown in figure below. At the instant the rod is horizontal,

a) find its angular speed. (6 pts)
b) find the magnitude of its angular acceleration. (6 pts)
c) find the x and y components of the acceleration of its center of mass. (6 pts)
d) find the horizontal and vertical components of the force exerted by the pivot. (2 pts)



V. A student sits on a freely rotating stool holding two weights, each of mass 3.0 kg (see figure below). When his arms are extended horizontally, the weights are 1.0 m from the axis of rotation and he rotates with an angular speed of 0.75 rad/s. The moment of inertia of the student plus stool is 3.0 kg·m^2 and is assumed to be constant. The student pulls the weights inward horizontally to a position 0.3 m from the rotation axis.

a) Find the new angular speed of the student. (7 pts)
b) Find the kinetic energy of the rotating system before and after he pulls the weights inward. (7 pts)
c) Who does the work to change the kinetic energy? Find the amount of work and specify the sign in your answer. (6 pts)

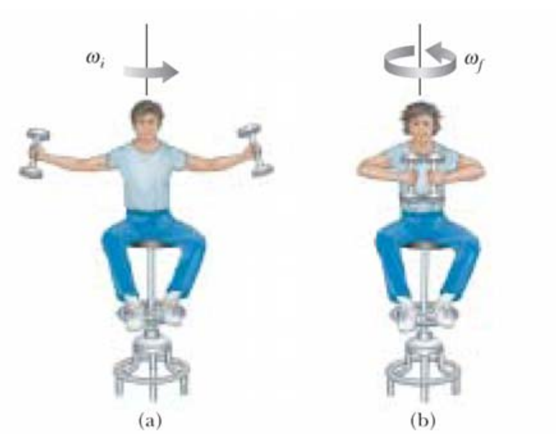
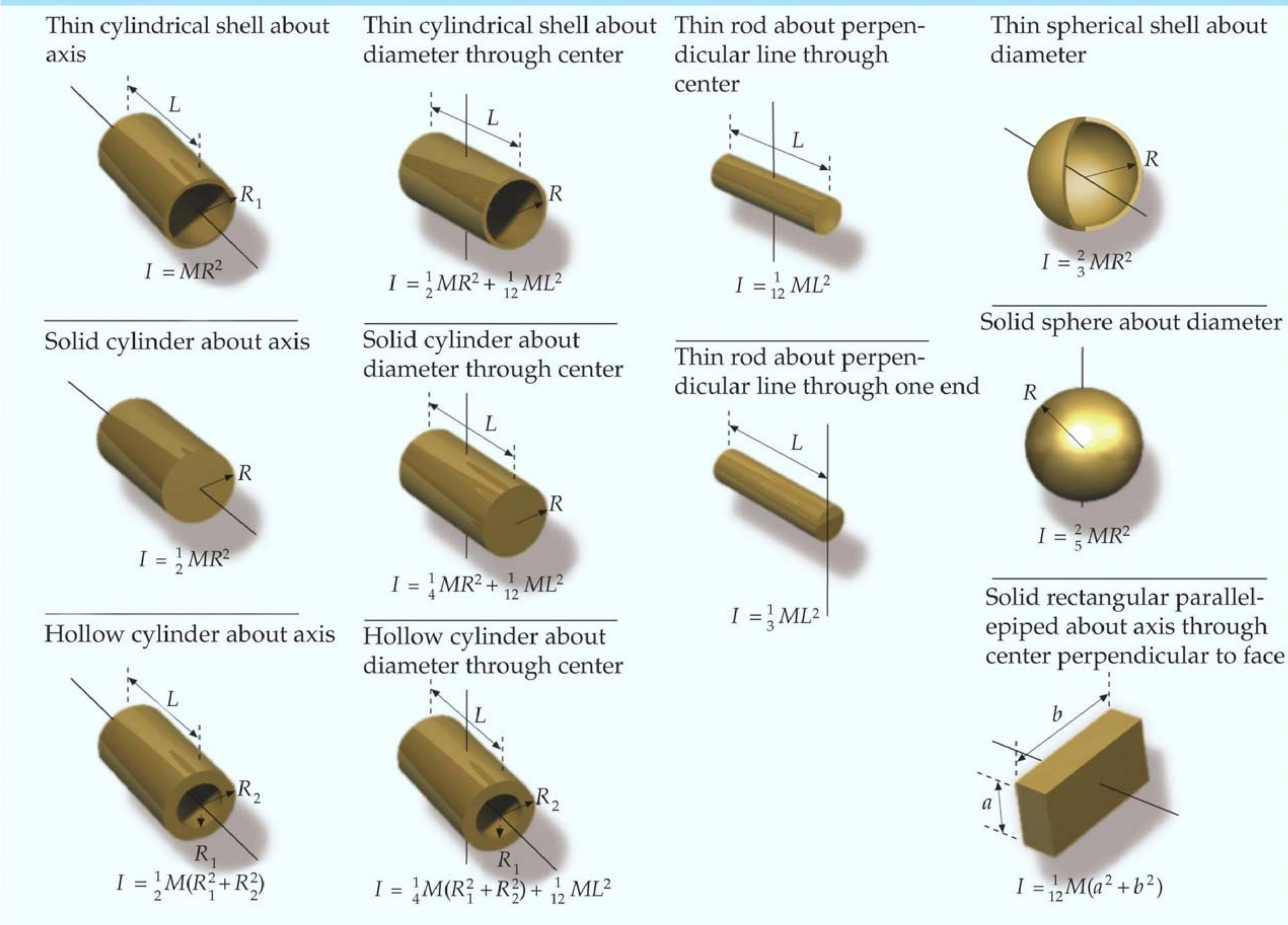


Table 9-1

Moments of Inertia of Uniform Bodies of Various Shapes



A disk is a cylinder whose length L is negligible. By setting $L = 0$, the above formulas for cylinders hold for disks.