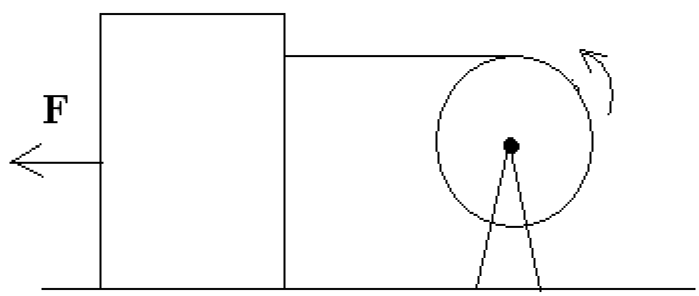
1. (25 POINTS) CHAPTER 10. A thin, light horizontal string is wrapped around the rim of a 4.00-kg solid uniform disk that is 30.0 cm in diameter. A 2.00-kg box is connected to the left end of the string and moves to the left along the ground horizontally *with friction.* The coefficient of KINETIC friction between the bottom of the box and the ground's horizontal surface is μ = 0.400.

The box is subjected to a leftward horizontal force of magnitude F = 50. 0 N parallel to the ground. The disk is rotates *counter- clockwise* about a fixed axis attached to a steel structure bolted to the ground:

(a) (15 points) What is *a*, the linear acceleration magnitude the box?
(b) (10 points) What is the tension T in the string?



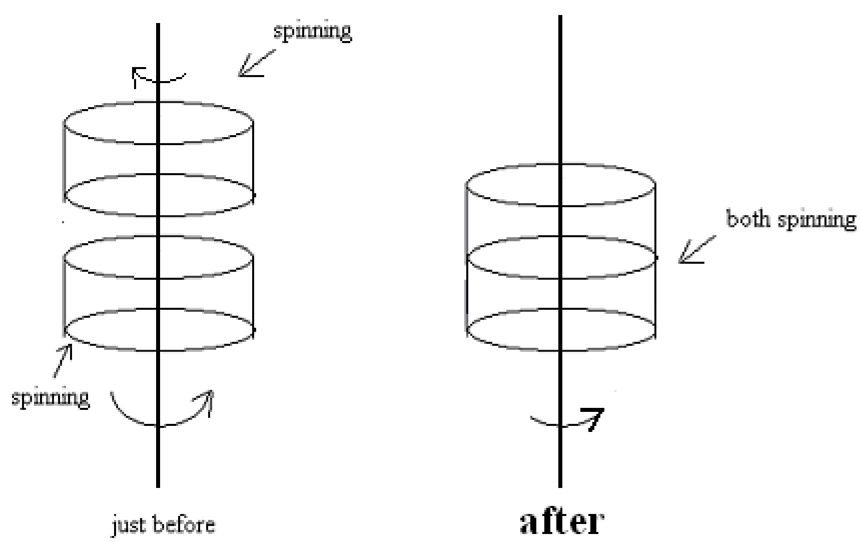
2. (40 POINTS) *During* *FALL*, a well known Chabot professor performs a classroom demonstration using two *identical* wooden turntables in the shape of flat uniform disks. Each turntable has radius R = 1.00 m and mass M = 4.00 kg. CHECK OUT DIAGRAM BELOW BEFORE READING ON.

The bottom turntable is initially rotating at angular velocity ω_i = 10.00 rad/s about a vertical axis through its center. Suddenly the professor vertically drops, from directly above, a spinning disk on the rotating bottom turntable as shown.

The top identical disk has initial angular speed 2.00 rad/s spinning in the *opposite direction* along the common axis looking down. The disks have aligned circumferences as shown *after impact* and turn together as one unit with common angular speed.

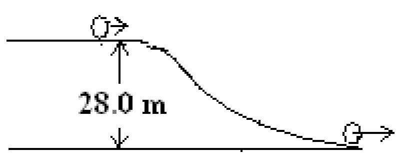
In other words, the top disk lands on the bottom one along the turntables' common central axis of rotation, *sticks* to bottom turntable's surface and turns with bottom one *without slipping*. Below is a schematic of the system just before and after top disk lands on bottom one.

(a) (30 points) What is the common final angular velocity ω_f of the system after the top disk lands on bottom one? SHOW ALL WORK!
(b) (10 points) Assuming the axis shown runs vertically up and down the page, what is the direction, Up or Down, and MAGNITUDE of angular momentum of the system?



3. (7 POINTS) In a small town just north of Bend Oregon, a solid uniform ball in the shape of a sphere rolls *without slipping* DOWN a hill. It's part of an outdoor high school physics experiment. AT THE TOP OF THE HILL THE LINEAR SPEED OF THE CENTER OF MASS IS V_{cm} = 25.0 m/s. At the BOTTOM of the hill the ball is moving horizontally. NO FRICTION anywhere on the surface. Use conservation of energy.

What is the linear speed V_{cm} of the center of mass at the bottom of the hill ? Hint: Do not forget *rotational* kinetic energy and the (linear) relationship between linear speed V_{cm} and rotational, angular speed ω.



4. (40 points)

One end of a uniform beam of mass 50-kg is attached to a wall with a hinge. A cable supports the other end. The relevant angles are shown. In particular, the cable makes an angle of 60-degrees with the vertical wall and the beam makes an angle of 60-degrees with the horizontal. Other needed angles *must be derived.* SHOW ALL WORK!

(a) (32 points) Find the tension T in the cable. SHOW ALL WORK!

(b) (4 points) Find the horizontal component F_h of the force of the hinge on the beam.

(c) (4 points) Find the vertical component F_v of the force of the hinge on the beam.

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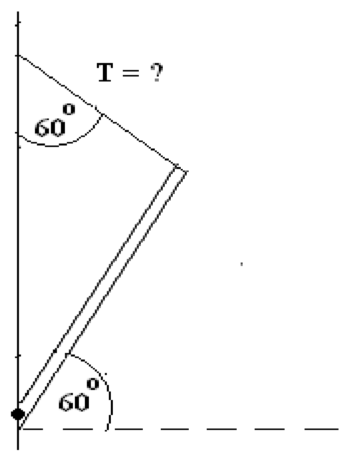


5. (44 POINTS) In a Chabot College physics lab experiment, a piece of balsa wood is completely submerged under the water. The wood is *at rest* and is tethered by a string to the bottom of a container of water. The balsa wood has volume is 1.34×10^{-6} m^3 and density of 0.16×10^3 kg/m^3. Water, on the other hand, has density 1.00×10^3 kg/m^3. Answer the following questions and show all work and reasoning.

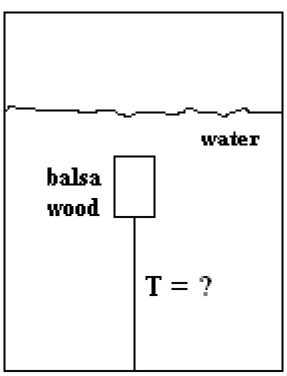
(a) (6 points) What is the direction of the buoyant force acting on the wood, *up or down* ? Circle "*up" or "down*."

(b) (6 points) What is the direction of the tension force acting on the wood, *up or down* ? Circle "*up" or "down*." ?

(c) (6 points) What is the direction of the force of gravity acting on the wood, *up or down* ? Circle "*up" or "down*." ?

(d) (22 points) What is the magnitude T of the tension in the string?

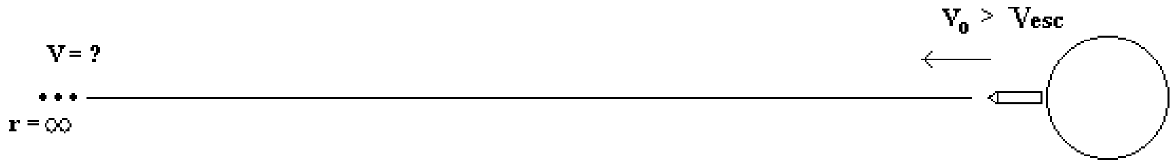
(e) (4 POINTS) Suppose the string was *cut*, setting the tension T to ZERO. What would be the *upward* acceleration *a* of the balsa wood piece in this water, before it hits the surface?



6. (26 points) GRAVITATIONAL POTENTIAL ENERGY. [THE 2D VECTOR PROBLEMS WILL BE ON FINAL EXAM PART 2.]

See Figure. A rocket is fired from the surface of the earth with initial velocity $V_o = 3 \cdot V_{ESC}$. What is the velocity V when the rocket reaches $r = \infty$?

Express your answer in terms of V_{ESC} .



7. (43 POINTS) A block of mass 4.00 kg is attached to a horizontal spring. No friction! At t = 0, the mass has position x_o = 0.402 m and velocity v_o = -5.03 m/s. The force constant of the spring is k = 299 N/m.
(a) (13) What is the amplitude A of the oscillations ?
(b) (13) What is the phase constant Φ_o?
Assume the x-position obeys the equation:

$$x = A\cos(\omega t + \phi_o)$$

(c) (7 points) What are the *two* values of x when the *spring potential energy equals the block's kinetic energy? Show your work!*
(d) (7 points) What are the *two* values of x when the *block's kinetic energy is zero? Show your work!*
(e) (3 points)* What is the value of x when the *spring potential energy is zero? Show your work!