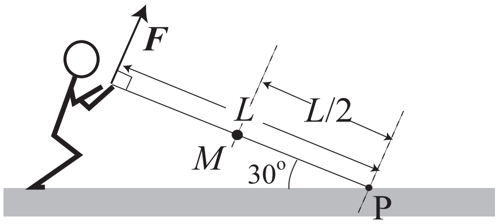
Physics 101 (S11) **Q7A**

Name: ____________________ **Section:** __________ **Score:** __________**/20**

1. At the center of a light bar of length L is attached a point mass (= a block whose size you can ignore) of mass M. The bar makes an angle 30° with the horizontal. The bar can rotate freely around the point P in the figure. You can ignore the mass of the bar.



(a) You are supporting this bar at one end with the force $\boldsymbol{F}$ which is perpendicular to the bar as noted in the figure. Write the magnitude of the force F in terms of M and g (or find the ratio F/Mg), where g is the acceleration of gravity. [5]

(b) You stop supporting it, and just leave the bar, which starts to rotate around P. Write the initial angular acceleration α of the bar in terms of g and L. [5]

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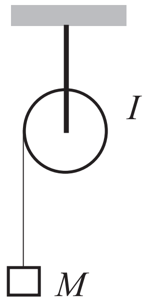
2. There is a drum whose moment of inertia around its axle is I. Around it is wound a flexible string from which hangs a block of mass M as illustrated below. The radius of the drum is R.

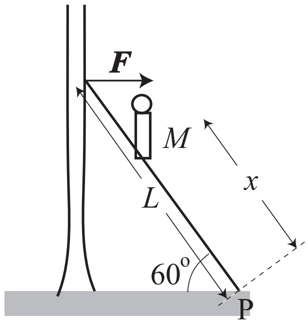


(a) Initially, the block and the drum are stationary. The block is gently released. After descending a certain distance L, the kinetic energy of the block is E. Write its momentum in terms of M and E. [5]

(b) Find the kinetic energy of the drum at the same moment in terms of I, R, M and E. [5]

Name: ____________________ **Section:** __________ **Score:** __________/**20**

1. A light ladder of length L leans against a smooth wall, making an angle of 60° with the horizontal. A person of mass M climbs up the ladder. You may ignore the weight of the ladder and the friction between the wall and the ladder. You may assume that there is a sufficient static friction between the ground and the ladder at point P.



(a) If the magnitude of the force from the wall F exceed F_c, the wall breaks. Express the maximum distance x from the bottom of the ladder along the ladder the person can climb up in terms of F_c, M, L and the acceleration of gravity g. [5]

(b) When the person climbs up to L/2 along the ladder, the wall collapses and the force $\boldsymbol{F}$ vanishes. What is the angular acceleration α of the ladder around its bottom point P? Write α in terms of L and g. [5]

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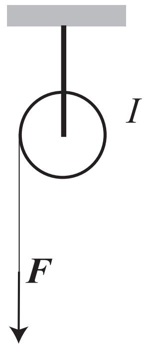
2. There is a drum whose moment of inertia around its axle is I. A flexible string is wound around the drum. The radius of the drum is R. The drum can rotate without friction around the axle.

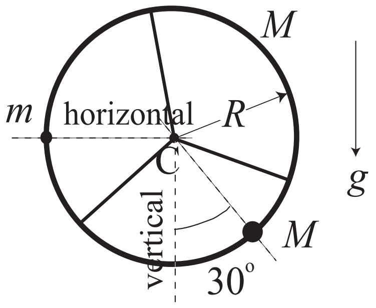


(a) Initially, the drum is at rest. A constant force whose magnitude is F is then applied downward on the string. What is the angular speed ω of the drum when the string has been pulled by a distance L. Write the angular speed ω of the drum in terms of L, I and F. [5]

(b) Suppose the mass of the drum is doubled, but I is maintained by appropriately changing its size. What happens to the angular speed if you repeat the same experiment. You must justify your answer. [5]

Name: ________________ **Section:** ________ **Score:** ________/20

1. Two point masses (= blocks whose sizes you can ignore) with mass m and M, respectively, are fixed on the hoop of radius R and mass M (the same M) as illustrated below. The hoop can rotate freely around its horizontal axle through the center C. The line connecting the center C and mass M makes an angle of 30° with the vertical as illustrated below. Ignore the masses of the spokes.



(a) The hoop with the fixed point masses is stationary. What is the ratio m/M? [5]

(b) Now, the point mass of mass m is removed, and the hoop starts to rotate. What is the initial angular acceleration α of the hoop? [5]

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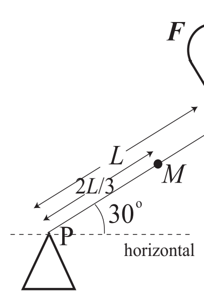
2. A uniform disk of radius R and mass M is initially rotating with a kinetic energy E.

(a) A 'break shoe' (a small box in the figure) applies a kinetic friction force F along the rim of the disk. How many rotations ρ_0 does the disk make before its kinetic energy is halved (see the illustration (a) above)? [5]

(b) Now, the break shoe is moved inside the disk and the same friction force is applied at the position which is distance $R/2$ away from the center (see the illustration (b) above). The disk makes ρ rotations before coming to a halt. Which is larger, ρ this time or ρ_0 in (a)? You must justify your answer. [5]

Name: ____________ **Section:** ________ **Score:** ________/20

1. On a light rod (ignore its mass) of length L is a point mass (= a block whose size you may ignore) of mass M fixed at a point that is $2L/3$ from the pivot P, around which the rod can rotate freely. At the other end of the rod is a balloon exerting a vertically upward force of magnitude F as illustrated below.



(a) The rod makes an angle 30° with the horizontal and the whole system is stationary. What is F in terms of M and the acceleration of gravity g? [5]

(b) Now, the string holding the balloon is cut. What is the angular acceleration of the rod immediately after the cut? [5]

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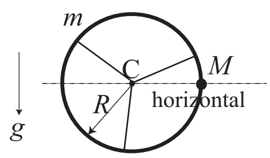
2. A uniform hoop of radius R and mass m is in the vertical plane and can rotate freely around the horizontal axle through the center C of the hoop. A point mass of mass M is fixed on the hoop. Its initial position is as illustrate below. Ignore the masses of the spokes.



(a) Suppose $m = M$. The system is initially at rest. The hoop is gently released to rotate. When the point mass reaches the lowest point, what is its speed V_0? [5]

(b) Suppose M is much larger than m (say, $M = 1000m$). Is the speed V of the point mass at the bottom faster than or slower than the answer V_0 in (a)? You must justify your answer. [5]