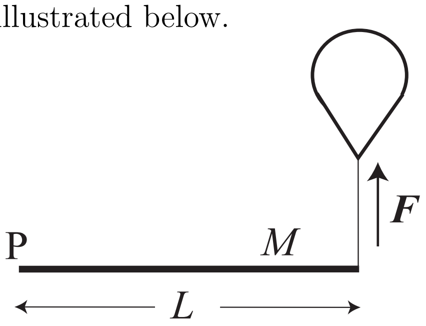
Physics 101 (F11) **Q7A**

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

1. A uniform stick of mass $M = 2.1$ kg and length $L = 1.2$ m is initially horizontally at rest. Its one end is fixed to a fulcrum P around which the stick can rotate freely. The other end is suspended by a balloon as illustrated below.



(a) What is the magnitude of the force acting on the stick from the fulcrum at P? [5]

(b) The balloon punctures and the force $\boldsymbol{F}$ is gone, so the stick starts to rotate around P. What is the (magnitude of the) initial angular acceleration of the stick? (The moment of inertia of a uniform rod around its end is given by $I = ML^2/3$; you may treat the gravitational force as acting at the center of mass of the stick.) [5]

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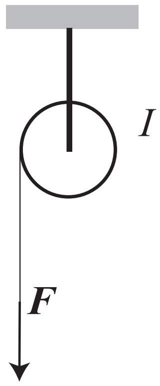
2. Around a uniform disk of radius $R = 0.3$ m and mass $M = 2.2$ kg is a string, which is pulled down with a constant force $\boldsymbol{F}$.



(a) When the string is pulled down over a distance of $D = 0.3$ m, the angular speed of the disk reaches $\omega = 3.1$ rad/s. What is the magnitude F of the constant force $\boldsymbol{F}$? [5]

(b) Suppose the magnitude of the constant pulling force is halved, but the distance D is the same. What is the angular speed of the disk in this case? [5]

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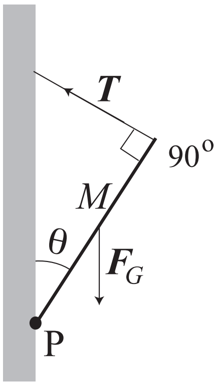
1. One end of a uniform bar of length $L = 1$ m and mass $M = 2.5$ kg is fixed at a fulcrum P. At the other end is attached a massless string, which hangs the bar from the wall as illustrated below.

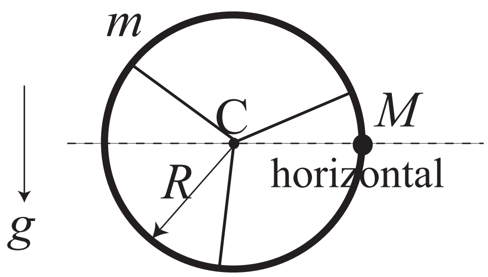


(a) The angle $\theta = 30°$. What is the tension T in the string? [5]

(b) Just after the string snaps, what is the angular acceleration of the rod around P? (The moment of inertia of a uniform rod around its end is given by $I = ML^2/3$; you may treat the gravitational force as acting at the center of mass of the rod.) [5]

(**2** on the next page)

2. A hoop of radius $R = 0.5$ m and mass $m = 4$ kg can rotate freely in a vertical plane around a horizontal axle through the center C (Ignore the masses of the spokes). On the hoop is fixed a small ball of mass $M = 2$ kg, which is initially at the height of the axle as illustrated.



(a) What is the angular speed ω of the hoop when the ball reaches its lowest position? Assume that initially the system is at rest. [5]

(b) We wish to make the ball complete one rotation around the center. What minimum initial angular speed of the hoop do you need? (Hint: stare at (a) and you will see the answer almost without any calculation, although some justification should be written.) [5]

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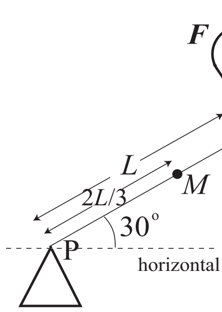
1. Around a fulcrum P can freely rotate a massless bar of length $L = 3$ m. At its other end is attached a balloon exerting an upward force of magnitude F. At a distance 2 m from P fixed is a point mass of mass $M = 12$ kg.



(a) Initially, the system is at rest. What is the magnitude of the force on the fulcrum P? [5]

(b) Just after the string snaps, what is the angular acceleration of the point mass? [5]}

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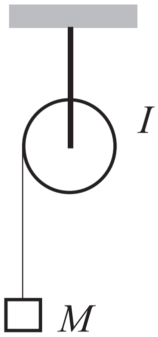
2. Around a disk of radius $R = 0.5$ m and mass $m = 4$ kg is a massless string to which a block of mass $M = 2$ kg is attached. The disk can rotate around its center freely in the vertical plane (corresponding to the sheet of this paper). Initially, the block is going up with a speed $v = 2$ m/s.



(a) To what height h will the block climb up? [5]

(b) Suppose we double the masses (i.e., $m \to 2m$, $M \to 2M$) but keep R, what happens to h? [5]

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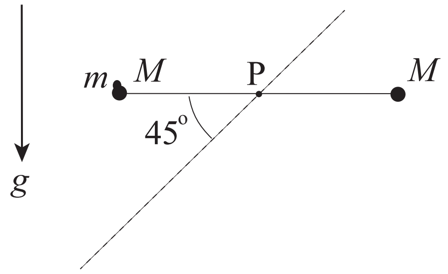
1. Two identical small balls of mass $M = 2$ kg are attached to the ends of a massless stick of length $L = 2$ m as illustrated below. On one of the balls is further attached a small mass of $m = 1$ kg as illustrated below.



(a) Initially, the stick is horizontal and at rest. Then, it is released gently to rotate around the midpoint P of the stick in the vertical plane (the sheet of this paper). What is the angular acceleration immediately after the release? [5]

(b) What is the torque around P when the stick makes an angle 45° with the horizontal (the dotted line in the figure)? You must give the correct unit. [5]

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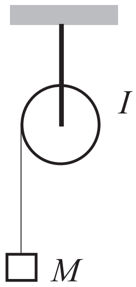
2. A drum of radius 0.5 m with a moment of inertia $I = 12$ kg·m^2 around its horizontal axle is suspended from the ceiling. Around it is wound a massless string which hangs a block of mass $M = 5$ kg as illustrated below. Initially, the (upward) speed of the block and the tangential speed of the outer rim of the drum are identical and 2 m/s.



(a) What is the height of the highest point of the center of mass of the block measured from its initial height? [5]

(b) When the block reaches its highest point, the string is cut. When the block returns to the initial height, is its speed larger or smaller than its initial speed? You must justify your answer.[5]