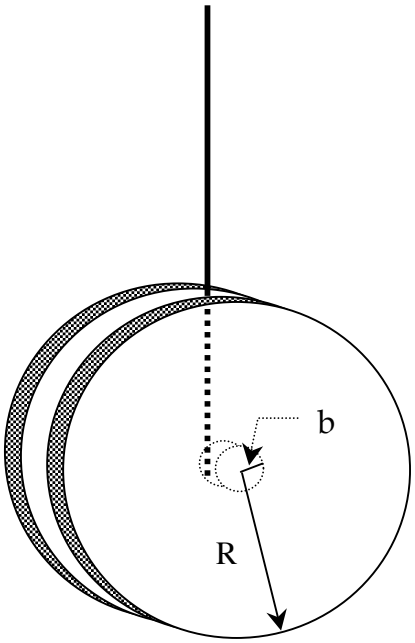
This problem is open book and open notes. You may not consult or confer with anyone *other than Mr. Burns*. Full credit will be awarded for each problem only if the correct answer is accompanied by sufficient work that is presented in such a manner that the logic and mathematical operations are clear and easy to follow. All answers must be boxed, labeled and accompanied by the appropriate units. Do each problem on a separate sheet.

1. (20) A yo-yo is constructed from two disks each with a mass of M and a radius R and a moment of inertia, $I = \beta MR^2$. The two disks are connected by a "massless" axle of radius, b. A string is wound several times around the axle, and then its end is held stationary while the yo-yo is released from rest, dropping as the string unwinds.



a. Derive expressions for the linear acceleration of the yo-yo and the tension in the string in terms of M, β, b, R and g.

b. To verify the correctness of your derived relationship for the acceleration of the yo-yo, consider what happens when $b \rightarrow R$. Discuss what you observe about this relationship and its units.

In addition (and here is the interesting part), what happens to the acceleration as $b \rightarrow 0$? Look also at your relationship for tension. To what does this relationship simplify? How is this physically consistent to the relationship for the acceleration as $b \rightarrow 0$? Explain.

c. Derive an expression (in terms of M, β, b, R and g) for the speed of the yo-yo after it has completed 3 revolutions.

d. Derive an expression (in terms of M, β, b, R and g) for the time it takes the yo-yo to make 3 revolutions.