AP Physics 1
Falling Mass on Rotating Disk
2015 – 2016 [1]

1 Background

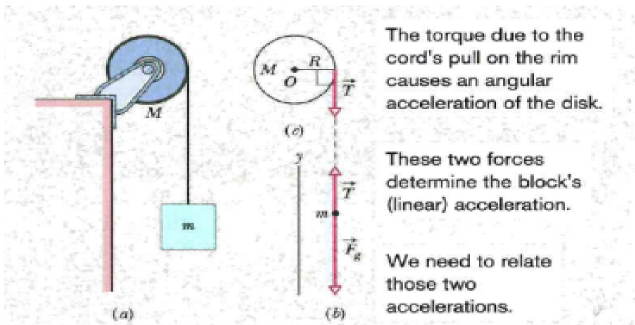


Fig. 10-18 (*a*) The falling block causes the disk to rotate. (*b*) A free-body diagram for the block. (*c*) An incomplete free-body diagram for the disk.

The above *figure* shows a uniform disk, with mass M and radius R, mounted on a fixed horizontal axle. A block with mass m hangs from a massless cord that is wrapped around the rim of the disk. A typical problem, such as this, asks one to calculate the *angular acceleration* of the disk, the *acceleration* of the falling mass, the *tension* in the rope, the *torque* on the disk, and the *time* it takes for the falling mass to hit the ground.

In one-dimensional dynamics, we only focused on the falling mass, drawing a free-body diagram and determining the forces acting on it. In rotational dynamics, however, we must also take into account the rotation of the disk. So in this lab we will expand our focus to include both the falling mass, using our knowledge of Newton's Laws for objects treated as particles, *and* the rotating disk, developing Newton's Laws to account for objects rotating about a fixed axis.

[1] Last Modified: 2016/03/29 at 2:45am

2 Key Ideas

First, taking the block as a system, we can relate its acceleration a to the forces acting on it with Newton's Second Law

$$F = ma \tag{1}$$

Second, taking the disk as a system, we can relate its angular acceleration α to the torque τ acting on it with Newton's Second Law for Rotation

$$\tau = I\alpha \tag{2}$$

Third, to combine the motions of the block and disk, we use the fact that the linear acceleration at of the disk rim are equal

$$\alpha = a_t \tag{3}$$

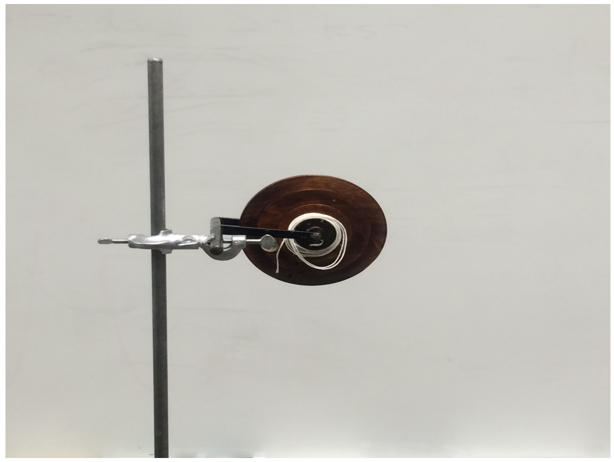
Fourth, we will assume that the *moment of inertia* of our rotating disk is

$$I = \frac{1}{2}MR^2 \tag{4}$$

3 Objective

Students will, using Newton's Second of Rotation and their knowledge of dynamics, predict the time it takes for the falling mass to hit the ground for two different radii and two different masses. Students will then verify their predictions experimentally and calculate the percent difference bewteen the two times. All student data will be recorded in the data table provided.

Set-Up



First, draw a free-body diagram of the falling block attached to the disk.

Second, measure the *mass* of the disk.

Third, measure the *radius* for two different radii.

Fourth, measure the *mass* of two different blocks.

Fifth, calculate the *tension* in the string.

Sixth, calculate the *torque*.

Seventh, calculate the *angular acceleration*.

Eighth, measure the *distance* from the center of the disk to the ground.

Ninth, calculate and *predict* the *time* it takes for the falling mass to hit the ground.

Tenth, *experimentally* verify the *time* it takes for the falling mass to hit the ground.

Eleventh, calculate the *percent difference* between the calculated/predicted acceleration and the experimental acceleration.

Twelfth, submit formal lab report on *Monday, April 11, 2016* according to the following rubric. **N.B.: This is your last formal lab report of the year.**

Grading Rubric

RUBRIC D: Ability to design & conduct an application experiment					
	Scientific Ability	Missing	Inadequate	Needs improvement	Adequate
D1	**Is able to identify the problem to be solved**	No mention is made of the problem to be solved.	An attempt is made to identify the problem to be solved but it is described in a confusing manner.	The problem to be solved is described but there are minor omissions or vague details.	The problem to be solved is clearly stated.
D2	**Is able to design a reliable experiment that solves the problem**	The experiment does not solve the problem.	The experiment attempts to solve the problem but due to the nature of the design the data will not lead to a reliable solution.	The experiment attempts to solve the problem but due to the nature of the design there is a moderate chance the data will not lead to a reliable solution.	The experiment solves the problem and has a high likelihood of producing data that will lead to a reliable solution.
D3	**Is able to use available equipment to make measurements**	At least one of the chosen measurements cannot be made with the available equipment.	All of the chosen measurements can be made, but no details are given about how it is done.	All of the chosen measurements can be made, but the details about how they are done are vague or incomplete.	All of the chosen measurements can be made and all details about how they are done are provided and clear.
D4	**Is able to make a judgment about the results of the experiment**	No discussion is presented about the results of the experiment	A judgment is made about the results, but it is not reasonable or coherent.	An acceptable judgment is made about the result, but the reasoning is flawed or incomplete. Or uncertainties are not taken into account. Or assumptions are not discussed. The result is written as a single number.	An acceptable judgment is made about the result, with clear reasoning. The effects of assumptions and experimental uncertainties are considered. The result is written as an interval.
D5	**Is able to evaluate the results by means of an independent method**	No attempt is made to evaluate the consistency of the result using an independent method.	A second independent method is used to evaluate the results. However there is little or no discussion about the differences in the results due to the two methods.	A second independent method is used to evaluate the results. The results of the two methods are compared correctly using experimental uncertainties. But there is little or no discussion of the possible reasons for the differences when the results are different.	A second independent method is used to evaluate the results and the evaluation is correctly done with the experimental uncertainties. The discrepancy between the results of the two methods, and possible reasons are discussed.
D7	**Is able to choose a productive mathematical procedure for solving the experimental problem**	Mathematical procedure is either missing, or the equations written down are irrelevant to the design.	A mathematical procedure is described, but is incorrect or incomplete, due to which the final answer cannot be calculated. Or units are inconsistent.	Correct and complete mathematical procedure is described but an error is made in the calculations. All units are consistent.	Mathematical procedure is fully consistent with the design. All quantities are calculated correctly with proper units. Final answer is meaningful.
D8	**Is able to identify the assumptions made in using the mathematical procedure**	No attempt is made to identify any assumptions.	An attempt is made to identify assumptions, but the assumptions are irrelevant or incorrect for the situation.	Relevant assumptions are identified but are not significant for solving the problem.	All relevant assumptions are correctly identified.
D9	**Is able to determine specifically the way in which assumptions might affect the results**	No attempt is made to determine the effects of assumptions.	The effects of assumptions are mentioned but are described vaguely.	The effects of assumptions are determined, but no attempt is made to validate them.	The effects of the assumptions are determined and the assumptions are validated.

Data Table

M	R	m	T	τ	α	a_t	d	t predicted	t calculated	% difference