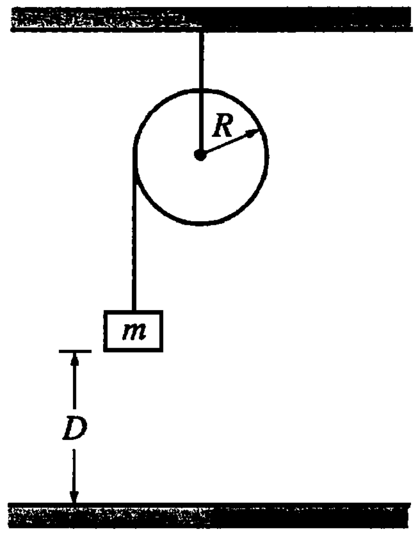
AP® Physics C: Mechanics
2004 Sample Student Responses

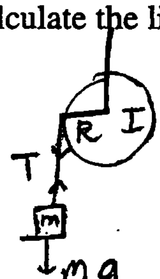
A1



Mech. 2.

A solid disk of unknown mass and known radius R is used as a pulley in a lab experiment, as shown above. A small block of mass m is attached to a string, the other end of which is attached to the pulley and wrapped around it several times. The block of mass m is released from rest and takes a time t to fall the distance D to the floor.

(a) Calculate the linear acceleration a of the falling block in terms of the given quantities.



$\frac{1}{2}at^2 = D$, $a = \frac{2D}{t^2}$

(b) The time t is measured for various heights D and the data are recorded in the following table.

D (m)	t (s)
0.5	0.68
1	1.02
1.5	1.19
2	1.38

i. What quantities should be graphed in order to best determine the acceleration of the block? Explain your reasoning.

$D - t^2$ graph should be graphed because a is $2 \times$ slope of graph

$D = \frac{1}{2}at^2$, $\frac{\Delta D}{\Delta t^2} = \frac{1}{2}a$, $a = 2\frac{\Delta D}{\Delta t^2}$

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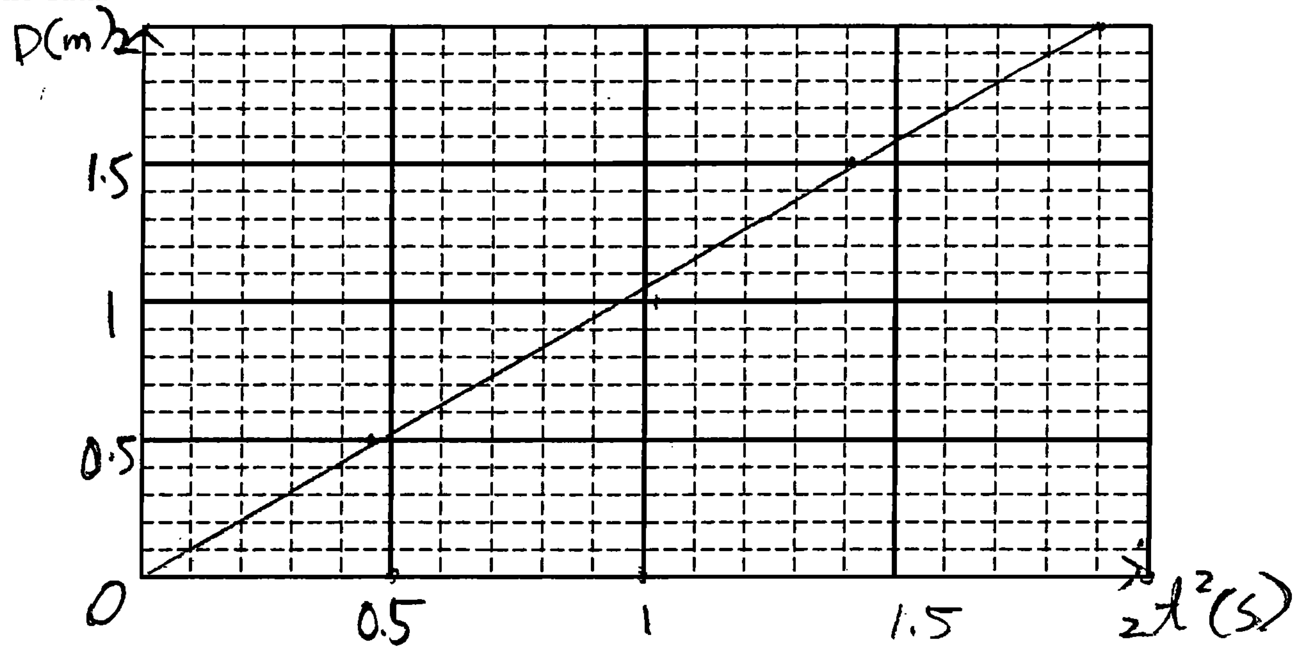
ii. On the grid below, plot the quantities determined in (b)i., label the axes, and draw the best-fit line to the data.

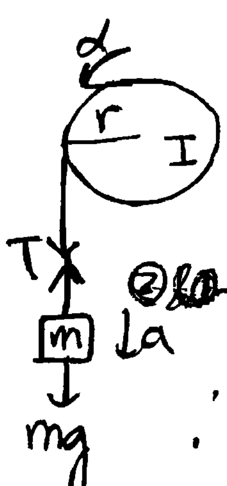


iii. Use your graph to calculate the magnitude of the acceleration.

~~th~~ slope of graph $\doteqdot 1\ m/s^2$

$a \doteqdot 2\ m/s^2$

(c) Calculate the rotational inertia of the pulley in terms of *m*, *R*, *a*, and fundamental constants.



$mg - T = ma$ — ①

$TR = I\alpha$ — ②

$a = R\alpha$ — ③

② → $mg - \frac{I\alpha}{R} = ma$, ③ $mg - \frac{Ia}{R^2} = ma$

$\therefore I = \frac{mR^2}{a}(g-a)$, $\therefore I = mR^2\left(\frac{g}{a} - 1\right)$

(d) The value of acceleration found in (b)iii, along with numerical values for the given quantities and your answer to (c), can be used to determine the rotational inertia of the pulley. The pulley is removed from its support and its rotational inertia is found to be greater than this value. Give one explanation for this discrepancy.

because the string wrapped around the pulley has mass, as the string unwrapped, torque acting on pulley increases, and a also increases since $I = mR^2\left(\frac{g}{a} - 1\right)$, as a increases I decreases.

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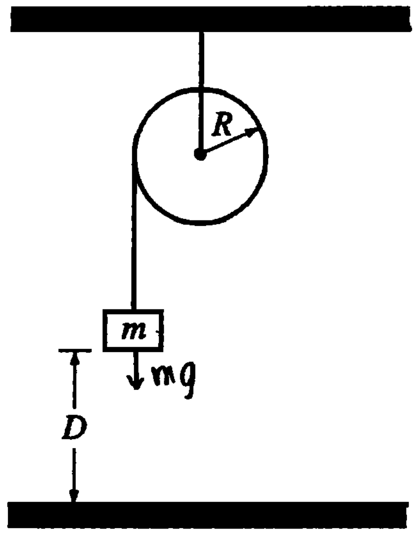
B1



Mech. 2.

A solid disk of unknown mass and known radius R is used as a pulley in a lab experiment, as shown above. A small block of mass m is attached to a string, the other end of which is attached to the pulley and wrapped around it several times. The block of mass m is released from rest and takes a time t to fall the distance D to the floor.

(a) Calculate the linear acceleration a of the falling block in terms of the given quantities.

The acceleration of the block is constant, so we can use kinematics:

$$d_y = \cancel{V_{0y}t}^{\,0} + \frac{1}{2}at^2$$

$$D = \frac{1}{2}at^2 \qquad \boxed{a = \frac{2D}{t^2}}$$

(b) The time t is measured for various heights D and the data are recorded in the following table.

D (m)	t (s)	t^2 (s^2)
0.5	0.68	.46
1	1.02	1.04
1.5	1.19	1.42
2	1.38	1.90

i. What quantities should be graphed in order to best determine the acceleration of the block? Explain your reasoning.

t^2 should be graphed as a function of D. This will give us:

$$t^2 = \frac{2}{a}(D)$$

We will have a linear relationship, so we will be able to calculate the slope. Then, we can set the slope equal to $\frac{2}{a}$ and calculate a.

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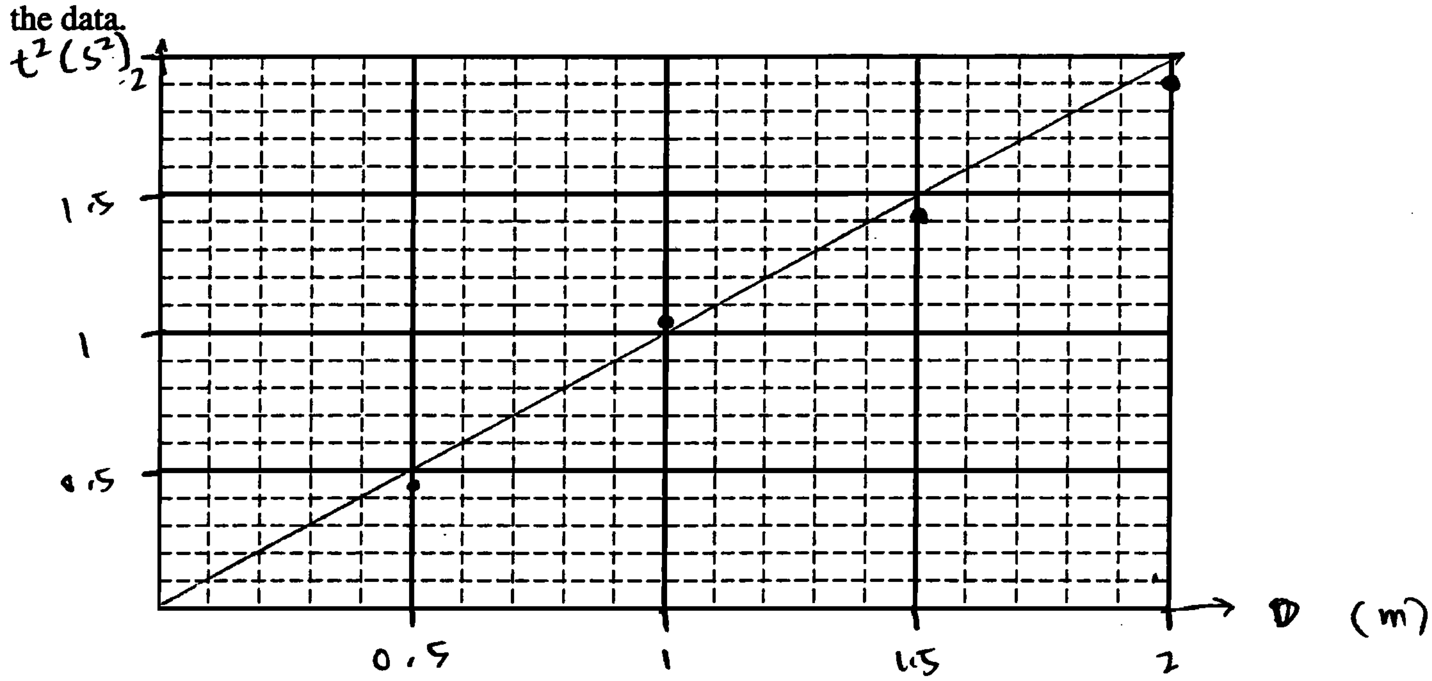
ii. On the grid below, plot the quantities determined in (b)i., label the axes, and draw the best-fit line to the data.



iii. Use your graph to calculate the magnitude of the acceleration.

The slope of the line of best fit = 1

$1 = \frac{2}{a}$ $\boxed{a = 2\ m/s^2}$

(c) Calculate the rotational inertia of the pulley in terms of *m*, *R*, *a*, and fundamental constants.

The angular acceleration of the pulley, $\alpha = \frac{a}{R}$. The force mg is acting at a distance R from the center of the pulley, so we have the relationship:

$mgR = I\alpha$

$mgR = I\frac{a}{R}$ $\boxed{I = \frac{mgR^2}{a}}$

(d) The value of acceleration found in (b)iii, along with numerical values for the given quantities and your answer to (c), can be used to determine the rotational inertia of the pulley. The pulley is removed from its support and its rotational inertia is found to be greater than this value. Give one explanation for this discrepancy.

There might be slipping between the pulley and the string. This would decrease the experimental value of the time it takes for the mass to fall.

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