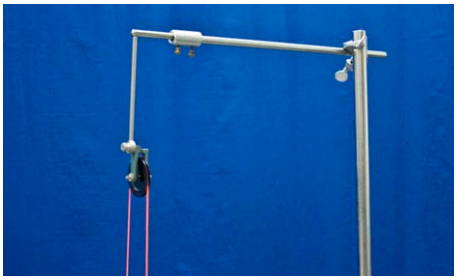
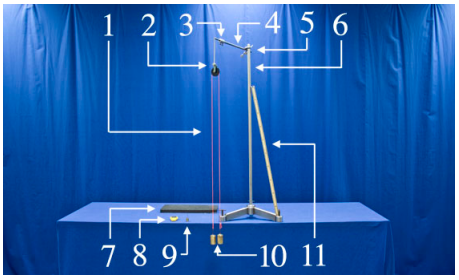
ATWOOD'S MACHINE 1G10.40

Mechanics | Newton's Second Law | Force, Mass and Acceleration





Concept:

Here is a classic textbook application of Newton's Laws. The analysis of forces and torques on the two masses and pulley gives

(1) $m_2 g - T_2 = m_2 a,$ (2) $T_1 - m_1 g = m_1 a,$

(3) $R(T_2 - T_1) = I\alpha = I\dfrac{a}{R} = \beta m_p R^2 \dfrac{a}{R} = \beta m_p R a$

Solve Equation (1), (2) and (3) to obtain the system's acceleration:

(4) $a = \dfrac{(m_2 - m_1)g}{m_1 + m_2 + \beta m_p}$

Note: Equation (4) is the net force on the system divided by its total mass, where βm_p is the effective rotational inertia of the pulley.

For constant acceleration the time to fall a distance h from rest is

(5) $t = \sqrt{\dfrac{2h}{a}}$

Note: For h = 100 cm, m_1 = 500 g, m_2 = 550 g, $\beta = 1$, m_p = 10 g, and g = 980 cm/s^2, Equation (4) and (5) give t = 2.1 s.

Since $\beta m_p << m_1 + m_2$, the effect of the pulley may be neglected if desired.

Equipment:

1. String
2. Suspended Pulley (10 g disk)
3. Straight Rod Clamp
4. 1.5 ft Rod
5. Large Rod Clamp
6. Large Stand
7. Foam Platform
8. Stopwatch
9. 50 g Weight
10. (2) 500 g Weights
11. Meter Stick

Procedure:

1. Verify that the 500 g weights are hanging from each end of the string that is suspended from the pulley.
2. Ask for a volunteer to act as a timer.
3. Hang the 50 g weight from the base of one of the 500 g weights.
4. Use the meter stick to hold the 550 g weight 1 meter above the foam platform.
5. As you release the weight, the volunteer starts the stopwatch.
6. The volunteer stops the stopwatch when the weight touches the foam platform.
7. Verify that the measured time (~ 2 seconds) matches the calculated time (2.1 seconds).