Mech. 2.

You are to perform an experiment investigating the conservation of mechanical energy involving a transformation from initial gravitational potential energy to translational kinetic energy.

(a) You are given the equipment listed below, all the supports required to hold the equipment, and a lab table. On the list below, indicate each piece of equipment you would use by checking the line next to each item.

____ Track	X Meterstick	____ Set of objects of different masses
____ Cart	____ Electronic balance	____ Lightweight low-friction pulley
____ String	X Stopwatch	

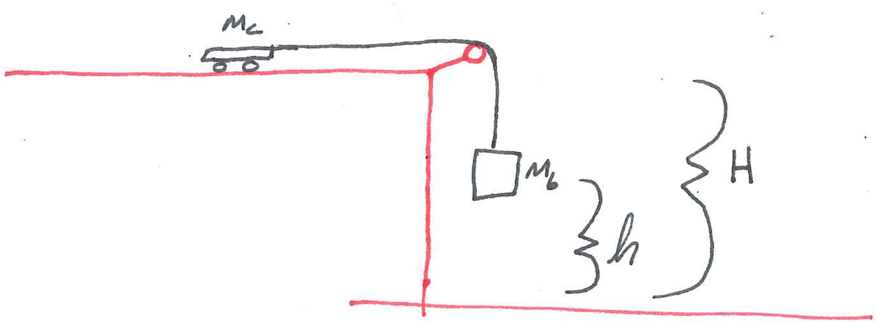
(b) Outline a procedure for performing the experiment. Include a diagram of your experimental setup. Label the equipment in your diagram. Also include a description of the measurements you would make and a symbol for each measurement.

Height needed for GPE 1pt.

Distance & time to calc velocity 1pt.

Diagram → Height Measurement 1pt.

Diagram → Distance Measurement 1pt.



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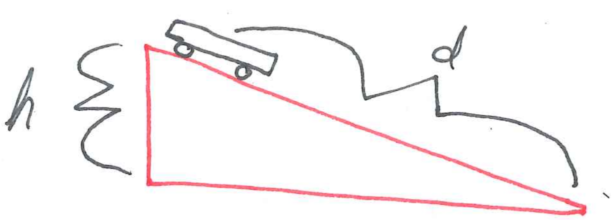

(c) Give a detailed account of the calculations of gravitational potential energy and translational kinetic energy both before and after the transformation, in terms of the quantities measured in part (b).

Initial Potential $U_{g_0} = m_c gH + m_b gh$ 1 pt.

Final Potential $U_{gf} = m_c gH$ 1 pt.

Initial Kinetic $KE_0 = \frac{1}{2} mv^2 = 0$ 1 pt.

Final Kinetic $KE_f = \frac{1}{2}(m_c + m_b)v_f^2$ 1 pt.

Instantaneous Velocity $d = \frac{1}{2}(v_0 + v_f)t$ 2 pts.

(d) After your first trial, your calculations show that the energy <u>increased</u> during the experiment. Assuming you made no mathematical errors, give a reasonable explanation for this result.

Cause for increase in energy 1 pt.

Explination related to cause 1 pt.

An unintentional push was applied to the cart, thus increasing the initial energy

(e) On all other trials, your calculations show that the energy <u>decreased</u> during the experiment. Assuming you made no mathematical errors, give a reasonable physical explanation for the fact that the average energy you determined decreased. Include references to conservative and nonconservative forces, as appropriate.

Reasonable cause for decrease 1 pt.

Explination related to cause 1 pt.

Friction is acting on the object causing the speed to decrease, thereby decreasing the energy.

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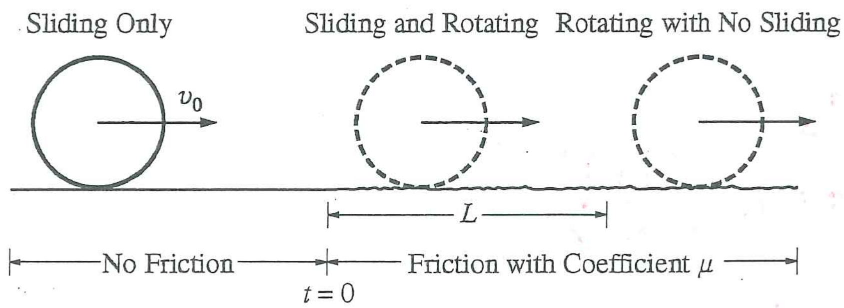

Mech. 3.

A ring of mass M, radius R, and rotational inertia MR^2 is initially sliding on a frictionless surface at constant velocity v_0 to the right, as shown above. At time $t = 0$ it encounters a surface with coefficient of friction μ and begins sliding and rotating. After traveling a distance L, the ring begins rolling without sliding. Express all answers to the following in terms of M, R, v_0, μ, and fundamental constants, as appropriate.

(a) Starting from Newton's second law in either translational or rotational form, as appropriate, derive a differential equation that can be used to solve for the magnitude of the following as the ring is sliding and rotating.

i. The linear velocity v of the ring as a function of time t

$\sum F = -F_f = ma$ $\quad F_f = \mu N = \mu mg$

$-\mu \cancel{m} g = \cancel{m} a \rightarrow -\mu g = a \rightarrow \frac{dv}{dt} = -\mu g$

$a = \frac{dv}{dt}$

ii. The angular velocity ω of the ring as a function of time t

$\tau = MR^2 \alpha$ $\quad \alpha = \frac{d\omega}{dt}$

$\tau = \mu M g R$ $\quad \frac{d\omega}{dt} = \frac{\mu g}{R}$

(b) Derive an expression for the magnitude of the following as the ring is sliding and rotating.

i. The linear velocity v of the ring as a function of time t

$\int_{v_0}^{v} dv = \int_0^t -\mu g \, dt \Rightarrow v = v_0 - \mu g t$

ii. The angular velocity ω of the ring as a function of time t

$\int_0^\omega d\omega = \int_0^t \frac{\mu g}{R} dt \rightarrow \omega = \frac{\mu g t}{R}$

(c) Derive an expression for the time it takes the ring to travel the distance L.

$v = d/t$
$v = R\omega$

$$v_0 - \mu g t = R\left(\frac{\mu g t}{R}\right)$$

$$t = \frac{v_0}{2\mu g}$$

(d) Derive an expression for the magnitude of the velocity of the ring immediately after it has traveled the distance L.

$$v = v_0 + at$$

$$v = v_0 - \mu g\left(\frac{v_0}{2\mu g}\right)$$

$$v = \frac{v_0}{2}$$

(e) Derive an expression for the distance L.

$$L = \int_0^t (v_0 - vgt)\,dt$$

$$L = \int_0^{\frac{v_0}{2\mu g}} (v_0 - vgt)\,dt = \left[v_0 t - \frac{1}{2}\mu g t^2\right]_0^{\frac{v_0}{2\mu g}}$$

$$L = \frac{3v_0^2}{8\mu g}$$