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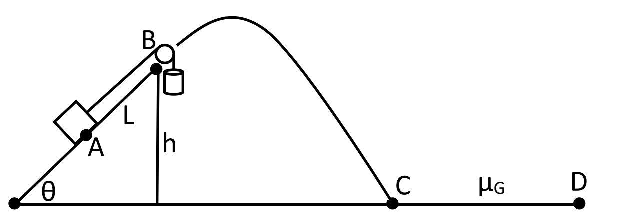
11/2/2021
Section: S

Problem:

Leaping Larry decided to make a laborious launcher for his luxury luge using a pulley and ramp system (see diagram). His method was to attach one end of a massless stretchless rope to a barrel of rocks and to hold the other end of the rope. He placed the rope over a massless frictionless pulley, and then walked down the ramp far as down possible to point A. When he sat in the luge he accelerated up the ramp to point B and then launched off the top at the same angle as the ramp (all while releasing the rope and avoiding the pulley). He flew through the air as a projectile to point C, smoothly transitioning all of his (net) speed into the horizontal direction, and eventually slid to a stop at point D. Note: Ignore any height differences between luge height, barrel height, and size of the pulley, and the diagram is not drawn to scale.

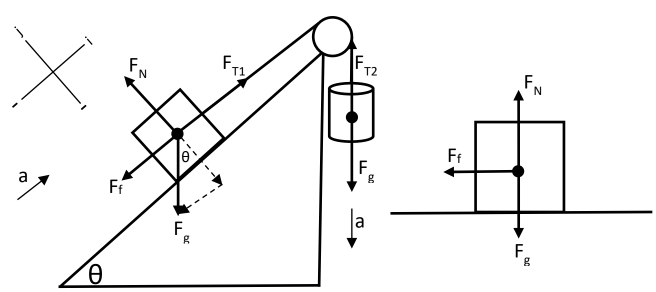
Diagram:



Givens:

$m_L = 27$ kg
$m_B = 42$ kg
$\theta = 33°$
$\mu_R = 0.12$
$h = 7.9$ m
$\Delta x_{BD} = 51$ m
$\mu_G = ???$

FBD's:



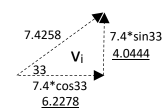
The first step was to find equations for both forces of tension and then set them equal to find acceleration.

$$\Sigma F_j: F_N - F_g cos\theta = m_1 a_1$$
$$\underline{F_N = m_1 g cos\theta}$$
$$\Sigma F_i: F_{T1} - F_g sin\theta - F_f = m_1 a_1$$
$$F_{T1} - m_1 g sin\theta - \mu F_N = m_1 a_1$$
$$\underline{F_{T1} = m_1 a_1 + m_1 g sin\theta + \mu(m_1 g cos\theta)}$$
$$\Sigma F_{2y}: F_{T2} - F_{g2} = m_2 a_2$$
$$\underline{F_{T2} = m_2 a_2 + m_2 g}$$
$$m_1 a_1 + m_1 g sin\theta + \mu(m_1 g cos\theta) = m_2 a_2 + m_2 g$$
$$a_1(m_1 + m_2) = m_2 g - m_1 g sin\theta + \mu(m_1 g cos\theta)$$
$$a_1(42 + 27) = 42 * 9.8 - 27 * 9.8 * sin33 - .12 * 27 * cos33 * 9.8$$
$$69a_1 = 411.6 - 144.11 - 26.6295$$
$$\underline{a = 3.4907\ m/s^2\ \nearrow}$$

With the acceleration, the final velocity is found.

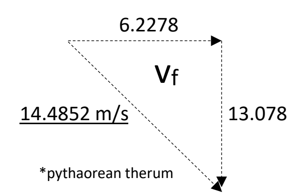
$$v_f^2 = v_i^2 + 2a\Delta x$$
$$v_f^2 = 2(3.4907)(7.9)$$
$$\underline{v_f = 7.4258\ m/s\ \nearrow}$$

Directional velocities coming off the ramp are used to find v_f and distance at C:



$$y_f = 0.5at^2 + v_i t + y_i$$
$$0 = -4.9t^2 + 4.04t + 7.9 \quad , solver$$
$$\underline{t = 1.74723\ sec}$$
$$x_f = 0.5at^2 + v_i t + x_i$$
$$x_f = (6.2278)(1.74723)$$
$$\underline{x_f = 10.8814\ m}$$

$v_{fx} = a\Delta t + v_{ix}$
$\underline{v_{fx} = 6.2278\ m/s}$
$v_{fy} = a\Delta t + v_{iy}$
$v_{fx} = -9.8(1.747) + 4.04$
$\underline{v_{fx} = -13.078\ m/s}$



$$x_{BD} - x_{BC} = x_{CD}$$
$$\underline{x_{CD} = 40.119\ m}$$

Use the distance and velocity to find aceleration:

$$v_f^2 = v_i^2 + 2a\Delta x$$
$$0 = 14.4852^2 + 2a(40.119)$$
$$\underline{a_{CD} = -2.615\ m/s^2}$$

Mu can now be calculated with second FBD and a_{CD}.

$$\Sigma F_y: F_N - F_g = ma$$
$$F_N = mg$$
$$\Sigma F_x: ma = -F_f$$
$$ma = -\mu F_N$$
$$-ma = \mu(mg)$$
$$-(27)(-2.615) = \mu(27)(9.8)$$
$$\mu(264.6) = 70.6042$$
$$\boxed{\mu = 0.2668}$$