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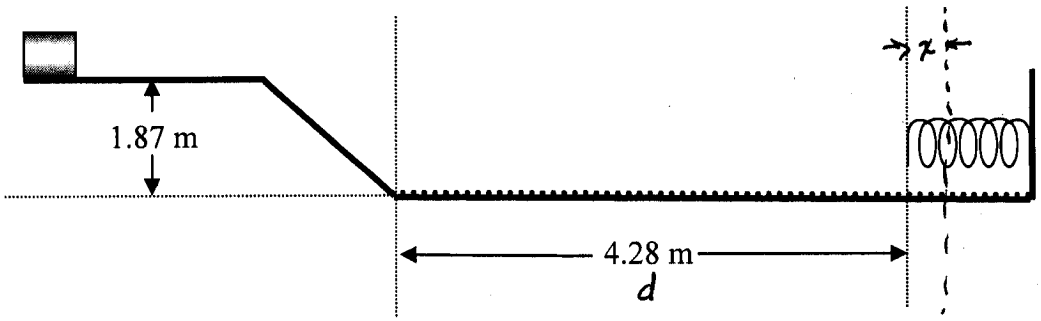
1. A block of mass 3.12 kg is sliding along the upper portion of a track. The upper portion and the ramp are frictionless. The block has a speed of 2.18 m/s on the upper portion. The vertical drop from the top to the bottom of the ramp is 1.87 m. At the bottom of the ramp the surface is rough and the coefficient of friction between the block and the ramp is 0.12. The block travels a distance of 4.28 m before it hits a spring which has a spring constant of 537 N/m. How far does the block compress the spring in order to come (momentarily) to rest? (25 points)



$$E_i + W_{NC} = E_f$$

$$\frac{1}{2}mv_i^2 + mgy_i - \mu_k mg(d+x) = \frac{1}{2}kx^2$$

$$\frac{1}{2}(3.12\,kg)(2.18\,m/s)^2 + (3.12\,kg)(9.8\,m/s^2)(1.87\,m) - .12(3.12\,kg)(9.8\,m/s^2)(4.28\,m + x)$$

$$= \frac{1}{2}(537\,N/m)x^2$$

$$57.2\,J + 7.41\,J - 15.7\,J - (3.67\,N)x = (268.5\,N/m)x^2$$

$$48.9\,J = (268.5\,N/m)x^2 + (3.67\,N)x$$

QUADRATIC EQN:

$$x = \frac{-3.67 \pm \sqrt{(3.67)^2 - 4(268.5)(-48.9)}}{2(268.5)}$$

$$= -.434\,m,\ +.420\,m$$

$$\boxed{x = .420\,m}$$

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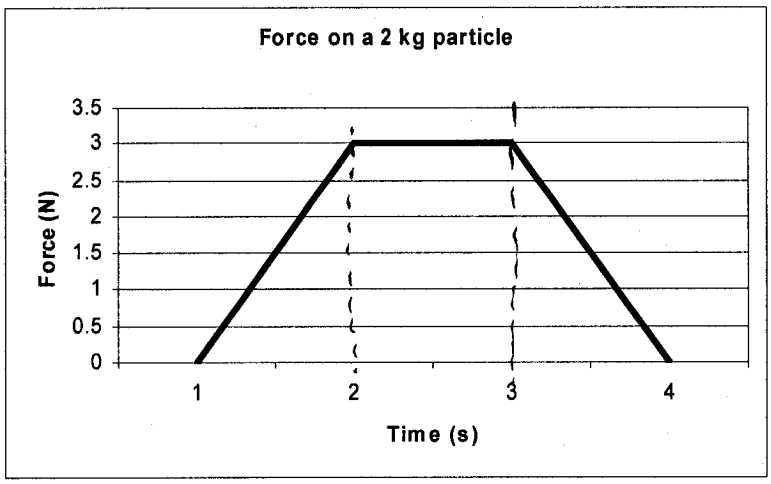
2. Given the following time varying force acting on a 2 kg particle initially at rest, Find:



a. The magnitude of the impulse caused by this time varying force. (5 points)

$$I = \int_{1s}^{4s} F\,dt = (1.5\ N\text{-}s + 3\ N\text{-}s + 1.5\ N\text{-}s)$$
$$= \boxed{6\ N\text{-}s}$$

b. The final velocity of the particle. (5 points)

$$I = \Delta p = p_f - \cancel{p_i}^{\,0} = 6\ N\text{-}s = (2\ kg)\,v_f$$
$$v_f = \boxed{3\ m/s}$$

c. The magnitude of the average value of the force from $t_1 = 1$ sec to $t_2 = 4$ sec. (5 points)

$$\bar{F}\,\Delta t = I = \bar{F}(3\ s) = 6\ N\text{-}s$$
$$\bar{F} = \boxed{2\ N}$$

d. What is the work done by this force? (5 points)

$$K_i = 0\ J$$
$$K_f = \tfrac{1}{2}(2\ kg)(3\ m/s)^2 = 9\ J$$
$$W = \Delta K = \boxed{9\ J}$$

e. What is the average power delivered by this force? (5 points)

$$\bar{P} = \frac{W}{\Delta t} = \frac{9\ J}{3\ s} = \boxed{3\ W}$$

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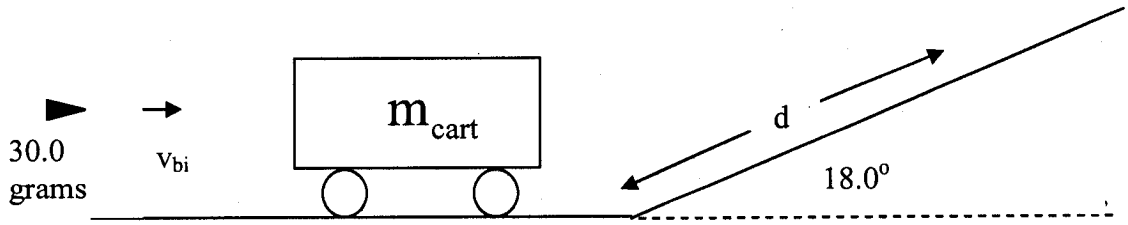
3. In the drawing below, a bullet of mass 30.0 grams is shot into a cart which is at rest. The bullet sticks into the cart. The initial velocity of the bullet v_{bi} is 315 m/s toward the right. The mass of the cart is 2.00 kg. (25 points)



How far (distance = d) does the cart roll up the hill before coming to a momentary (instantaneous) stop? The angle of the hill is 18.0°.

$$\vec{P}_i = \vec{P}_f \qquad \text{(During Collision)}$$

$$m_B v_B = (m_B + m_c) v_f$$

$$(0.030\ \text{kg})(315\ \text{m/s}) = (2\ \text{kg} + 0.03\ \text{kg}) v_f \Rightarrow v_f = 4.66\ \text{m/s}$$

$$E_i = E_f \qquad \text{(After Collision)}$$

$$\frac{1}{2}(\cancel{m_b + m_c}) v_f^2 = \cancel{(m_b + m_c)} g y = (\cancel{m_b + m_c}) g d \sin\theta$$

$$\frac{1}{2}(4.66\ \text{m/s})^2 = 9.8\ \text{m/s}^2\ d \sin 18^\circ$$

$$d = \boxed{3.59\ \text{m}}$$

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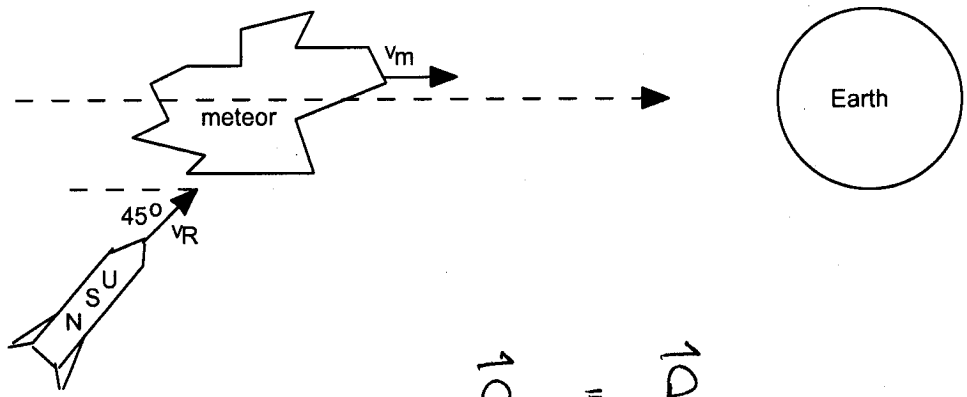
4~~3~~. A meteor of mass 1.4×10^6 kg is detected moving at 2000 m/s directly towards the earth. Your mission is to deflect the meteor from its current path by 25°, to ensure that it won't hit the earth. You are to use a rocket ship of mass 5.5×10^4 kg which will be fired at the meteor, at an angle of 45° to the meteor's current trajectory. If the rocket crashes onto the meteor and sticks, find the rocket speed required to achieve the 25° deflection. (25 points)



$$\vec{P}_i = \vec{P}_f$$

$$P_{x_i} = P_{x_i} = m_m v_m + m_R v_R \cos 45° = (m_m + m_R) v_f \cos 25°$$

$$P_{y_i} = P_{y_f} = m_R v_R \sin 45° = (m_m + m_R) v_f \sin 25°$$

(P_x)

$$(1.4 \times 10^6 \text{ kg})(2000 \text{ m/s}) + (5.5 \times 10^4 \text{ kg}) v_R (.707) = (1.455 \times 10^6 \text{ kg}) v_f \cos 25°$$

$$2.8 \times 10^9 \text{ kg m/s} + (3.89 \times 10^4 \text{ kg}) v_R = (1.32 \times 10^6 \text{ kg}) v_f$$

(P_y)

$$(5.5 \times 10^4 \text{ kg}) v_R (.707) = (1.455 \times 10^6 \text{ kg}) v_f \sin 25°$$

$$(3.89 \times 10^4 \text{ kg}) v_R = (6.15 \times 10^5 \text{ kg}) v_f$$

CALC:

$$v_R = \boxed{6.3 \times 10^4 \ \frac{m}{s}}$$

$$v_f = \boxed{3970 \text{ m/s}}$$