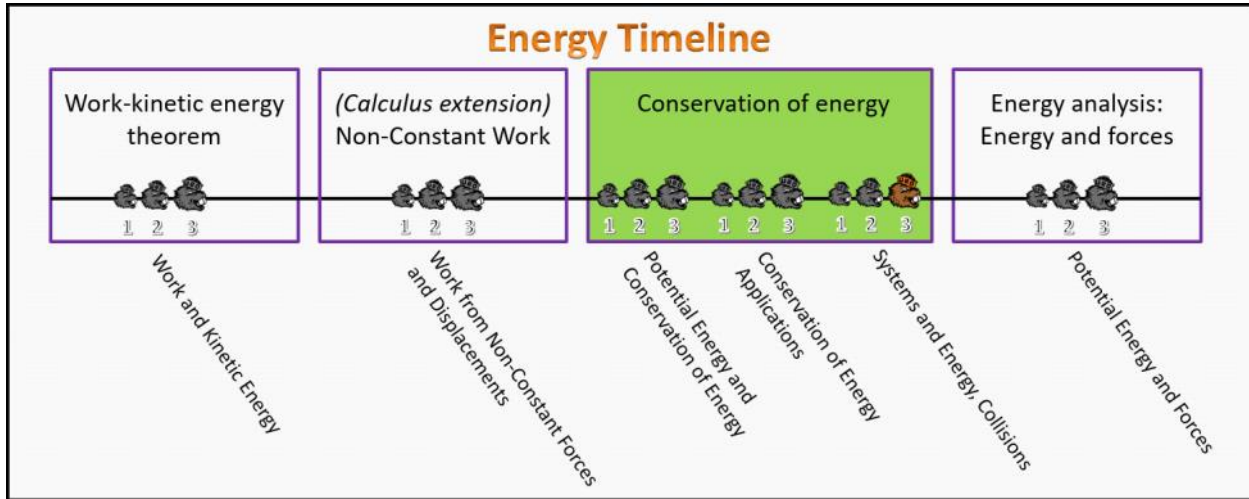


Conservation of Energy Foundation Stage (CE.L3.3)

Post-Lecture 3 Systems and Energy, Collisions



Questions

CE.L3.3-01

Description: Conservation of energy and Atwood's machine

Learning Objectives: [x]

Problem Statement: In an Atwood's machine one of the masses is twice the magnitude of the other.

(a) If both masses start from rest, which of the following expressions represents the velocity squared of the heavier mass after falling a distance h from its equilibrium position?

- (1) $v^2 = 2gh$
- (2) $v^2 = 3gh/2$
- (3) $v^2 = 2gh/3$
- (4) $v^2 = gh$
- (5) $v^2 = gh/2$

$$U_{i1}^g + KE_{i1} + U_{i2}^g + KE_{i2} + 2U_{int} = U_{1f}^g + KE_{1f} + U_{2f}^g + KE_{2f}$$

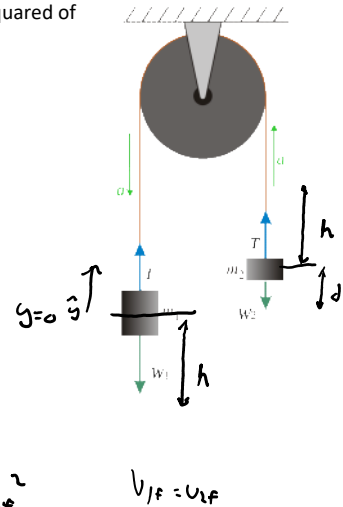
$$U_{i2}^g = U_{1f}^g + U_{2f}^g + KE_{1f} + KE_{2f}$$

$$m_2 g y_{i2} = m_1 g y_{1f} + m_2 g y_{2f} + \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2$$

$$m_2 g d = m_1 g (-h) + m_2 g (d+h) + \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2$$

$$0 = -m_1 g h + m_2 g h + \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2$$

$$0 = -m_1 g h + m_2 g h + \frac{1}{2} m_1 v_f^2 + \frac{1}{2} m_2 v_f^2$$



$$0 = -m_1gh + m_2gh + \frac{1}{2}m_1v_f^2 + \frac{1}{2}m_2v_f^2$$

$$0 = gh(m_2 - m_1) + \frac{1}{2}v_f^2(m_1 + m_2)$$

$$v_f^2 = \frac{2gh(m_2 - m_1)}{(m_1 + m_2)} \quad m_1 = 2m_2$$

$$= \frac{2gh(2m_2 - m_2)}{2m_2 + m_2}$$

$$= \frac{2ghm_2}{3m_2}$$

$$v_f^2 = \frac{2}{3}gh$$

(b) If the heavier mass falls a distance of 30 cm, how fast is the lighter mass traveling?

- (1) 0.707 m/s
- (2) 1.40 m/s
- (3) 1.96 m/s
- (4) 2.27 m/s
- (5) 4.21 m/s

$$v_f = \sqrt{\frac{2gh}{3}}$$

$$= \sqrt{\frac{2(9.8)(.3)}{3}}$$

$$v_f = 1.4 \text{ m/s}$$

CE.13.3-02

Description: Coupled masses across pulley with friction

Learning Objectives: [x]

Problem Statement: Three masses are connected via light strings and the aid of an ideal pulley, as shown in the figure. The mass m_2 is twice as massive as m_1 , while m_3 is three times as massive as m_1 . Starting from rest, m_3 is released and falls 1.30 m to the floor. If the speed of m_3 right before it hits the floor is 3 m/s, what is the coefficient of kinetic friction between the table and the blocks? (hint: use an energy analysis)

- (1) 0.139
- (2) 0.294
- (3) 0.385
- (4) 0.422
- (5) 0.571

ENERGY
SUBSTITUTION $m_1 + m_2 + m_3$ & SURFACE FRICTION

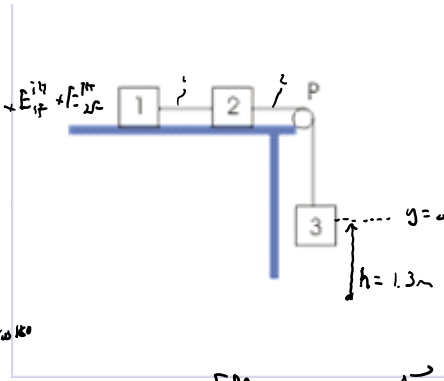


(5) 0.571

$$\cancel{KE_{1i}} + \cancel{KE_{2i}} + \cancel{KE_{3i}} + \cancel{U_{1i}} + E_{1i}^{pot} + E_{2i}^{pot} + \cancel{U_{2i}} = KE_{1f} + KE_{2f} + KE_{3f} + U_{3f} + E_{1f}^{pot} + U_{2f}^{pot}$$

$$0 = KE_{1f} + KE_{2f} + KE_{3f} + U_{3f} + \Delta E_{1i}^{pot} + \Delta E_{2i}^{pot}$$

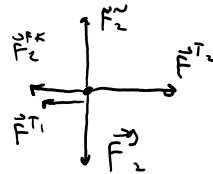
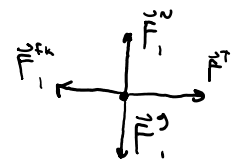
$$0 = \frac{1}{2}m_1 v_{1f}^2 + \frac{1}{2}m_2 v_{2f}^2 + \frac{1}{2}m_3 v_{3f}^2 + m_3 g h - F_{1i}^{pot} - F_{2i}^{pot}$$



FBD m_1



FBD m_2



$$0 = \frac{1}{2}m_1 v_f^2 + \frac{1}{2}m_2 v_f^2 + \frac{1}{2}m_3 v_f^2 - m_3 g h + \mu_k m_1 g \Delta r + \mu_k m_2 g \Delta r$$

$$0 = \frac{1}{2}v_f^2 (m_1 + m_2 + m_3) - m_3 g h + \mu_k g h (m_1 + m_2)$$

$$0 = \frac{1}{2}v_f^2 (m_1 + 2m_1 + 3m_1) - 3m_1 g h + \mu_k g h (m_1 + 2m_1)$$

$$m_2 = 2m_1$$

$$m_3 = 3m_1$$

$$0 = \frac{1}{2}v_f^2 (6m_1) - 3m_1 g h + \mu_k g h (3m_1)$$

$$0 = 3v_f^2 - 3gh + 3\mu_k gh$$

$$0 = 3(3)^2 - 3(9.8)(1.3) + 3\mu_k (9.8)(1.3)$$

$$\mu_k = 0.2936$$

CE.L3.3-03

Description: Finding the kinetic energy of colliding electrons

Learning Objectives: [x]

$$KE_i = KE_f$$

Problem Statement: Imagine two free electrons that collide elastically in an acidic solution where one electron was moving and the other electron was stationary. When the electrons separate the moving electron now has a velocity of 400 m/s and the stationary electron now has a velocity of 200 m/s. What was the initial kinetic energy of the moving electron?

- (1) 447 J
- (2) 100,000 J
- (3) 9.1×10^{-26} J
- (4) 4.1×10^{-28} J

$$\cancel{KE_{1i}} + \cancel{KE_{2i}} = KE_{1f} + KE_{2f}$$

$$\frac{1}{2}m_e v_{1i}^2 = \frac{1}{2}m_e v_{1f}^2 + \frac{1}{2}m_e v_{2f}^2$$

$$v_{1i}^2 = v_{1f}^2 + v_{2f}^2$$

$$KE_{ii} = \frac{1}{2} m_c v_i^2$$

$$= \frac{1}{2} (9.11 \times 10^{-31}) (200000)^2$$

$$KE_{ii} = 9.11 \times 10^{-26} \text{ J}$$

$$v_{i1}^2 = v_{1f}^2 + v_{2f}^2$$

$$v_{i1}^2 = 400^2 + 200^2$$

$$v_{i1}^2 = 200000 \frac{\text{m}^2}{\text{s}^2}$$

$$v_{i1} = 447 \text{ m/s}$$

CE.L3.3-04

Description: Calculating kinetic energy change in a momentum problem

Learning Objectives: [x]

Problem Statement: Anika, a 2.0 kg Falcon, is moving with an initial velocity of 15 m/s in the +x-direction. She collides with Betty, a 4.0 kg Falcon, initially moving at 7.0 m/s in the +x-direction. After the collision, the two birds stick together and move as one.

(a) What is the change in kinetic energy of the system as a result of the collision, in joules?

- (1) 32.3 J
- (2) 42.7 J
- (3) 68.9 J
- (4) -32.3 J
- (5) -42.7 J
- (6) -68.9 J

$$KE_i = KE_{1i} + KE_{2i}$$

$$= \frac{1}{2} m_1 v_{1i}^2 + \frac{1}{2} m_2 v_{2i}^2$$

$$= \frac{1}{2} (2) (15)^2 + \frac{1}{2} (4) (7)^2$$

$$KE_i = 323 \text{ J}$$

(b) Is this an elastic or inelastic collision?

- (1) elastic
- (2) inelastic
- (3) impossible to determine

$$KE_f = KE_{1f} + KE_{2f}$$

$$= \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2$$

$$= \frac{1}{2} m_1 v_f^2 + \frac{1}{2} m_2 v_f^2$$

$$KE_f = \frac{1}{2} v_f^2 (m_1 + m_2)$$

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$$m_1 v_{1ix} + m_2 v_{2ix} = (m_1 + m_2) v_{fx}$$

$$2(15) + 4(7) = (2+4) v_{fx}$$

$$v_{fx} = \frac{21}{3} \text{ m/s}$$

$$= \frac{1}{2} \left(\frac{29}{3} \right)^2 (2+4)$$

$$K_{Ef} = 280.3 \text{ J}$$

$$\Delta KE = K_{Ef} - K_{Ei}$$

$$= 280 - 323$$

$$\Delta KE = -43 \text{ J}$$