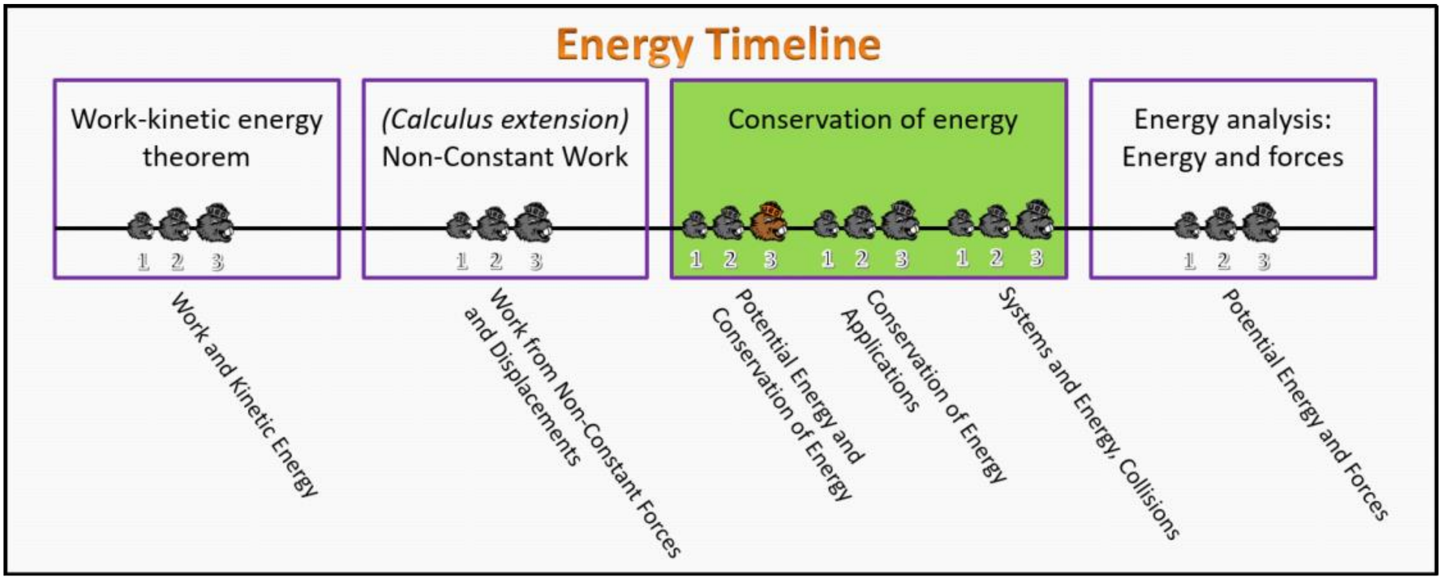
(CE.L1.3-sols) Practice Stage Solutions

Thursday, March 29, 2018 8:34 PM

Conservation of Energy

Foundation Stage (CE.L1.3)

Post-Lecture 1
Potential Energy and Conservation of Energy



Questions

CE.L1.3-01

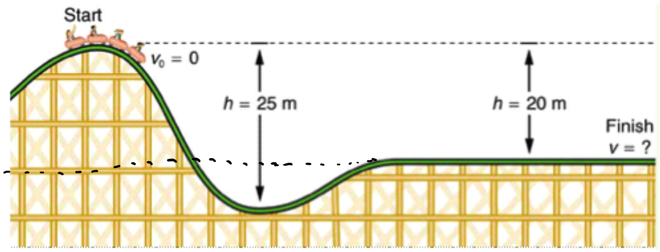
Description: Potential energy and energy conservation

Learning Objectives: [x]

Problem Statement: Consider the roller coaster in the figure.

System: M + E

(a) What is the final speed in m/s of the roller coaster shown in the figure if it starts from rest at the top of the 20.0 m hill and work done by frictional forces is negligible?



$\hat{y}$

y=0

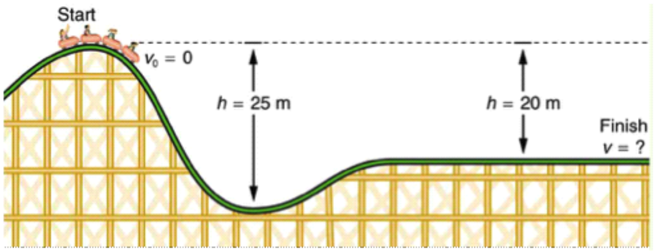
$$\cancel{KE_i}^{0} + U^g_i + \cancel{\Sigma W_{Ext}}^{0} = KE_f + \cancel{U^g_f}^{0}$$

$$U^g_i = KE_f$$

$$\cancel{m} g y_i = \frac{1}{2}\cancel{m} v_f^2$$

$$v_f = \sqrt{2 g y_i} = \sqrt{2(9.8)(20)} = \boxed{19.8 \ m/s}$$

(b) What is its final speed in m/s (again assuming negligible friction) if its initial speed is 5.00 m/s?



$$KE_i + U^g_i = KE_f$$

$$\frac{1}{2}\cancel{m}v_i^2 + \cancel{m}gy_i = \frac{1}{2}\cancel{m}v_f^2$$

$$\frac{1}{2}v_i^2 + gy_i = \frac{1}{2}v_f^2$$

$$\frac{1}{2}(5)^2 + (9.8)(20) = \frac{1}{2}v_f^2$$

$$\boxed{v_f = 20.4 \text{ m/s}}$$

CE.L1.3-02

Description: Conservation of energy on the moon

Learning Objectives: [x]

Problem Statement: Acceleration due to gravity on the moon is about 16% of the value of **g** on Earth.

(a) If an astronaut on the moon threw a moon rock to a height of 7.8 m, what would be its velocity as it struck the moon's surface?

System m+E

(1) The velocity of the rock as it hits the ground would be 3.0 m/s.
[✓ (2)] The velocity of the rock as it hits the ground would be 5.0 m/s.
(3) The velocity of the rock as it hits the ground would be 9.8 m/s
(4) The velocity of the rock as it hits the ground would be 12 m/s

$$\cancel{KE_i}^{0} + U^g_i + \cancel{\Sigma W_{EXT}}^{0} = KE_f + \cancel{U^g_f}^{0}$$

y=0 y↑

$$mgy_i = \frac{1}{2}mv_f^2$$

$$v_f = \sqrt{2gy_i}$$

$$= \sqrt{2(.16)(9.8)(7.8)} \approx \boxed{4.95 \text{ m/s}}$$

(b) How would the fact that the moon has no atmosphere affect the velocity of the falling moon rock? Explain your answer.

[✓ (1)] Due to the lack of air friction, there would be complete transformation of the potential energy into the kinetic energy as the rock falls to the moon's surface.

(2) Due to the lack of air friction, there would be incomplete transformation of the potential energy into the kinetic energy as

the rock falls to the moon’s surface.

(3) Due to the lack of air friction, energy would be created while it is transformed from potential energy into kinetic energy as the rock falls to the moon’s surface.

(4) There would be no effect on the velocity of the falling rock, and it would fall the same as if it's on Earth.

(c) When the rock hits the moon's surface, where does the kinetic energy from the rock go?

(1) Into potential energy between the rock and the moon.
(2) Into thermal energy in the moon only.
(3) Into thermal energy in the rock only
[✓ (4)] Into thermal energy in the moon and the rock.

CE.L1.3-03

Description: Energy and zero non-conservative work

Learning Objectives: [x]

Problem Statement: In a system where zero external work is being done on the system, which of the following statements are *necessarily* true?

(1) If the kinetic energy is decreasing than so is the total mechanical energy.
(2) If the potential energy is decreasing than so is the total mechanical energy.
(3) If the kinetic energy is decreasing then so is the potential energy.
(4) If the potential energy is decreasing than so is the kinetic energy.
[✓ (5)] The total mechanical energy is constant.
[✓ (6)] If the kinetic energy is increasing than the potential energy is decreasing.

CE.L1.3-04

Description: Energy and positive non-conservative work

Learning Objectives: [x]

Problem Statement: In a system where positive external work is being down on the system, which of the following statements are necessarily true?

(1) If the kinetic energy is decreasing, the potential energy must be increasing by the same amount.
[✓ (2)] If the kinetic energy is decreasing, the potential energy must be increasing by a larger amount.
(3) If the kinetic energy is increasing, the potential energy must be decreasing.
(4) If the kinetic energy is constant, the potential energy must be constant.
[✓ (5)] If the kinetic energy is constant, the potential energy must be increasing.
(6) If the kinetic energy is constant, the potential energy must be decreasing.

CE.L1.3-05

Description: Understanding the relationship between kinetic and potential energies

Learning Objectives: [x]

Problem Statement: Three pendulums all have the same length and start from the same height. The first pendulum is very light and has a mass of 67 **g**. The second pendulum has a mass of 1.5 kg. The final pendulum has a mass of 3.3 kg. Assume that the effects of air drag are negligible. Which pendulum attains the highest velocity?

(1) The 3.3 kg pendulum
(2) The 67 **g** pendulum
(3) The 1.5 kg pendulum
[✓ (4)] They will all attain the same maximum velocity.

Syst M + E

$$U^g_i = KE_f$$

$$\cancel{m} g y_i = \frac{1}{2}\cancel{m} v_f^2$$

$$v_f = \sqrt{2 g y_i}$$

↑ no mass ☺

CE.L1.3-06

Description: Proportional reasoning with spring potential energy

Learning Objectives: [x]

Problem Statement: A spring stretched by 8.0 cm has an energy of 20.J. The same spring is stretched by 12 cm. What is the elastic potential energy in the spring at this elongation?

[✓ (1)] 45 J
(2) 80 J
(3) 24 J
(4) 160 J

$$\frac{12}{8} = 1.5$$

(5) 13 J

$U^s = \frac{1}{2}kx^2$

$x \to 1.5x$

$U^s \to (1.5)^2 U^s$

$\underline{2.25}$

$(2.25)(20J) = 45\ J$

CE.L1.3-07

Description: Conservation of energy with train spring bumper

Learning Objectives: [x]

Problem Statement: A 5.00×10^{5} kg subway train is brought to a stop from a speed of 0.500 m/s in 0.400 m by a large spring bumper at the end of its track. What is the force constant k of the spring?

(1) 6.98×10^{5} N/m
(2) 6.25×10^{5} N/m
(3) 3.91×10^{5} N/m
[✓ (4) 7.81×10^{5} N/m]

System : M + S

$KE_i + \cancel{U^g_i}^{0} + \cancel{\Sigma W_{ext}}^{0} = \cancel{KE_f}^{0} + U^s_f$

$\frac{1}{2}\overset{\checkmark}{M}\overset{\checkmark}{v_i}^2 = \frac{1}{2}\overset{?}{k}\overset{\checkmark}{x_f}^2$

$\frac{1}{2}(5\times10^5)(.5)^2 = \frac{1}{2}k(.4)^2$

$k = 781250\ \frac{N}{m}$

CE.L1.3-08

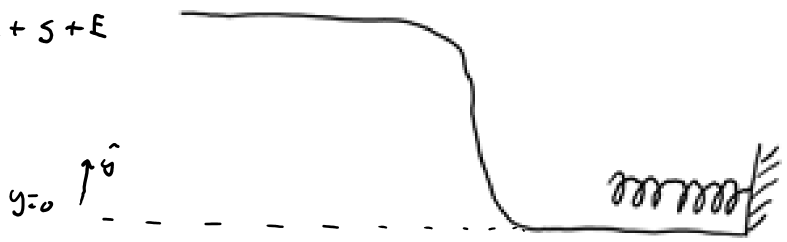
Description: Skier slides downhill into a spring

Learning Objectives: [x]

Problem Statement: A 70.0-kg skier is sliding at 4 m/s when they slide down a 2-m-high hill. At the bottom of the hill they run into a large 2800 N/m spring. How far do they compress the spring before coming momentarily to rest? Ignore friction.

[✓ (1) 1.17 m]
(2) 1.38 m
(3) 1.56 m
(4) 2.07 m
(5) 2.22 m

System M + S + E



$$KE_i + U^g_i + \cancel{U^s_i}^{\,0} + \cancel{\Sigma W_{Ext}}^{\,0} = \cancel{KE_f}^{\,0} + U^s_f + \cancel{U^g_f}^{\,0}$$

$$\frac{1}{2}\overset{\checkmark}{m}\overset{\checkmark}{v_i}^2 + \overset{\checkmark}{m}\overset{\checkmark}{g}\overset{\checkmark}{y_i} = \frac{1}{2}\overset{\checkmark}{k}\overset{?}{x_f}^2$$

$$\frac{1}{2}(70)(4)^2 + (70)(9.8)(2) = \frac{1}{2}(2800)x_f^2$$

$$\boxed{x_f = 1.17\ m}$$