Solutions to Period 6 Exercises

E.1 The potential energy of a body in the gravitational field of the Earth
a) increases as the mass of the body increases.
b) is increased if the body is raised.
c) is increased when the body is dropped.
d) is decreased if the body is warmed.
e) is correctly described by both a. and b. above.

From the equation,
\[ E_{\text{pot}} = M \cdot g \cdot h \]
the gravitational potential energy stored in a raised object is directly proportional to the height it is raised and to the mass of the object.

E.1 = e
E.2 In which of the following cases is the most work done on the object moved?

a) A 200 pound man climbs a 10-foot flight of stairs.
   \[ W = M \cdot g \cdot h = 200 \text{ lbs} \times 10 \text{ ft} = 2,000 \text{ ft-lbs.} \]

b) A 4000 pound automobile is lifted one-half of a foot by a hoist.
   \[ W = M \cdot g \cdot h = 4,000 \text{ lbs} \times 0.5 \text{ ft} = 2,000 \text{ ft-lbs} \]

c) A 2 pound stone falls 200 feet.
   \[ W = M \cdot g \cdot h = 2 \text{ lbs} \times -200 \text{ ft} = -400 \text{ ft-lbs} \]
   (Since the stone is falling, the work done on it is a negative number.)

d) A 5 pound bag of sugar is carried to the top of a building 600 feet high.
   \[ W = M \cdot g \cdot h = 5 \text{ lbs} \times 600 \text{ ft} = 3,000 \text{ ft-lbs} \]

e) The work done in all cases is the same.

E.2 = d
Robert is driving his car from Columbus to Cincinnati. While driving on the freeway, he maintains a steady speed of 50 miles per hour. After exiting from the freeway, he drives at a constant speed of 25 miles per hour. Relative to the kinetic energy of his car on the freeway, the kinetic energy of his car after exiting is

a) two times as large.
b) one-half as large.
c) four times as large.
d) one-fourth as large.
e) the same.

Use the equation \( E_{\text{kin}} = \frac{1}{2} M v^2 \) and make a ratio of the two kinetic energies.

Off the freeway \( E = \frac{1}{2} M (25)^2 = (1/ 2)^2 = 1/ 4 \)
On the freeway \( E = \frac{1}{2} M (50)^2 \)

\[ E.3 = d \]
E.4 Which has more kinetic energy, a 3,000 pound car moving at 75 MPH or an 18,000 pound truck moving at 25 MPH?

First, convert the quantities into metric units. Then use \[ E_{\text{kin}} = \frac{1}{2} M v^2 \]

**Car:**

\[
M = \frac{\text{Weight}}{g} = \frac{13,350 \, \text{N} \cdot \text{m}^2}{9.8 \, \text{m/s}^2} = 1,362 \, \text{kg}
\]

\[
v = \frac{75 \, \text{miles}}{1 \, \text{hour}} \times \frac{1,609 \, \text{m}}{1 \, \text{mile}} = 33.5 \, \text{m/s}
\]

\[
E_{\text{kin}} = \frac{1}{2} (1,362 \, \text{kg}) \times (33.5 \, \text{m/s})^2 = 681 \, \text{kg} \times 1122 \, \text{m}^2/\text{s}^2 = 764,252 \, \text{J} = 7.6 \times 10^5 \, \text{J}
\]

**Truck:** The truck’s weight is 6 times the car’s weight (18,000 lbs/3,000 lbs = 6)

\[
M = 6(\text{car mass}) = 6(1,362 \, \text{kg}) = 8,172 \, \text{kg}
\]

The truck’s velocity is 1/3 of the car’s velocity (25 mph/75 mph = 1/3)

\[
v = \frac{1}{3}(33.5 \, \text{m/s}) = 11.2 \, \text{m/s}
\]

\[
E_{\text{kin}} = \frac{1}{2} (8,172 \, \text{kg}) \times (11.2 \, \text{m/s})^2 = 4,086 \, \text{kg} \times 125 \, \text{m}^2/\text{s}^2 = 510,750 \, \text{J} = 5.1 \times 10^5 \, \text{J}
\]

E.4 = b
E.5 If a slide with a vertical height of 4 feet is totally frictionless, what speed would a person have at the bottom of the slide? (Hint: Ignoring friction, the gravitational potential energy at the top of the slide equals the kinetic energy at the bottom. The acceleration of gravity, $g$, in English units = 32 ft/ $s^2$.)

a) 11 ft/ s  
b) 16 ft/ s  
c) 128 ft/ s  
d) 256 ft/ s  

e) You need to know the mass of the person to answer the question.

Gravitational pot. energy = $E_{pot} = M \cdot g \cdot h$

Kinetic energy = $E_{kin} = \frac{1}{2} M \cdot v^2$

$M \cdot g \cdot h = \frac{1}{2} M \cdot v^2$

$2 \cdot g \cdot h = v^2 \quad \sqrt{2 \cdot g \cdot h} = v$

$v = \sqrt{2 \times 32 \text{ ft}/s^2 \times 4\text{ft}} = \sqrt{256 \text{ ft}^2/s^2} = 16 \text{ ft}/s$

E.5 = b
E.6 How much work must be done to push a 25 pound box to the top of the ramp? The force of friction between the box and the ramp is 10 pounds. The illustration shows the dimensions of the ramp.

\[
\begin{align*}
\text{Work to raise 25 lbs to a height of 12.5 ft:} & \quad W = Mgh = 25 \text{ lbs} \times 12.5 \text{ ft} = 312 \text{ ft-lbs} \\
\text{Work to move the box against friction:} & \quad W = FD = 10 \text{ lbs} \times 40 \text{ ft} = 400 \text{ ft-lbs} \\
\text{Total} & \quad = 312 \text{ ft-lbs} + 400 \text{ ft-lbs} = 712 \text{ ft-lbs}
\end{align*}
\]

\[E.6 = c\]
Solutions to Period 6 Exercises

E.1 = e
E.2 = d
E.3 = d
E.4 = b
E.5 = b
E.6 = c