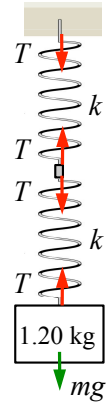


1. In the figure, a 1.22 kg mass is suspended from the ceiling by a series connection of two identical springs of negligible weight and spring constant,  $k = 100 \text{ N/m}$ , as shown in the figure. From the normal length, what is the stretch of the springs?

- A) Each spring stretches 12.0 cm.
- B) Each spring stretches 6.00 cm.
- C) The upper spring stretches 12.0 cm, and the lower spring doesn't stretch.
- D) The upper spring doesn't stretch, and the lower spring stretches 12.0 cm.
- E) Each spring stretches 122 cm.
- F) Each spring stretches 61 cm.
- G) The upper spring stretches 122 cm, and the lower spring doesn't stretch.
- H) The upper spring doesn't stretch, and the lower spring stretches 122 N.



$$F_{\text{Net}} = 0 \text{ on mass: } T = mg = 12.0 \text{ N}$$

$$\text{Each spring stretches } x, \text{ to create tension } T = kx$$

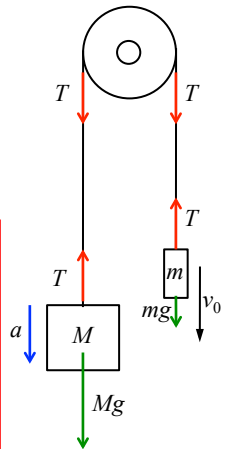
$$x = T / k = (12.0 / 100) \text{ m} = 12 \text{ cm}$$

2. A thin cord is draped over a massless and frictionless pulley. Attached to the ends are a large mass  $M$  and a small mass  $m$ . Initially, the small mass is moving downward and consequently the large mass is moving upward. The *magnitude* of the tension forces,  $T$  acting on the masses has what relationship to the weights?

- A)  $T > Mg$ , and  $T < mg$
- B)  $T > Mg$ , and  $T > mg$
- C)  $T > Mg$ , and  $T = mg$
- D)  $T < Mg$ , and  $T < mg$
- E)  $T = (M + m)g$
- F)  $T = Mg$ , and  $T > mg$
- G)  $T = Mg$ , and  $T < mg$
- H)  $T < Mg$ , and  $T > mg$

$Mg > mg$ , so acceleration is downward on left side and upward on right side.

$\vec{F}_{\text{Net}}$  on mass  $M$  points in the same direction (downward) as  $\vec{a}$ .  
 $T < Mg$ , and  $T > mg$ .



Due to insufficient practice with the Atwood's machine, I accepted all answers for this problem.

3. On a rough table, a horizontal force,  $F$ , is applied to a mass,  $m = 0.51 \text{ kg}$ , at rest but results in no motion. Once the force reaches a 2.0 N, the mass quickly achieves a constant velocity with a horizontal force of only 1.5 N. What are the coefficients of static friction ( $\mu_s$ ) and kinetic ( $\mu_k$ ) friction?

- A)  $\mu_s = 0.20$  and  $\mu_k = 0.15$
- B)  $\mu_s = 0.25$  and  $\mu_k = 0.20$
- C)  $\mu_s = 0.30$  and  $\mu_k = 0.25$
- D)  $\mu_s = 0.35$  and  $\mu_k = 0.30$
- E)  $\mu_s = 0.40$  and  $\mu_k = 0.30$
- F)  $\mu_s = 0.45$  and  $\mu_k = 0.35$
- G)  $\mu_s = 0.45$  and  $\mu_k = 0.40$
- H)  $\mu_s = 0.50$  and  $\mu_k = 0.38$

Max. static friction,  $f_{\text{Max}} = 2.0 \text{ N}$

$$f_{\text{Max}} = \mu_s F_{\perp} = \mu_s mg$$

$$\mu_s = f_{\text{Max}} / mg = 2.0 / (0.51)(9.81) = 0.40$$

Sliding friction,  $f_k = 1.5 \text{ N}$

$$f_k = \mu_k F_{\perp} = \mu_k mg$$

$$\mu_k = f_k / mg = 1.5 / (0.51)(9.81) = 0.30$$

4. A driver in a 1000.0 kg car traveling at 24 m/s slams on the brakes and skids to a stop. If the coefficient of kinetic friction between the tires and the road is 0.80, how long are the skid marks?

- A) 36.7 m
- B) 22.5 m
- C) 88.3 m
- D) 43.8 m
- E) 77.2 m
- F) 64.7 m
- G) 53.0 m
- H) 59.1 m

$$K_f = 0, \quad f_k = \mu_k F_{\perp} = \mu_k mg$$

$$W = K_f - K_i = -\frac{1}{2}mv_0^2$$

$$W = f_k \Delta x = \mu_k mg \Delta x$$

$$\mu_k mg \Delta x = -\frac{1}{2}mv_0^2$$

$$|\Delta x| = \frac{1}{2}v_0^2 / \mu_k g = (24)^2 / [2(0.80)(9.81)] \text{ m} = 36.7 \text{ m}$$

5. A super ball (highly elastic) bounces off the floor after dropping from rest 2.00m above the floor. If each collision with the earth is perfectly elastic the ball returns to the initial height on each bounce. If the ball loses exactly 10% of its energy on each bounce, what height above floor is reached after 10 bounces?

- A) 0.110 m  
B) 0.458 m  
C) 0.000 m  
D) 1.90 m
- E) 0.697 m  
F) 1.10 m  
G) 1.00 m  
H) 0.882 m

$$U_0 = mgh_0, \quad h_0 = U_0 / mg$$

$$\text{Loses 10\% on each bounce: } U_1 = 0.9U_0,$$

$$U_2 = 0.9U_1 = 0.9(0.9U_0) = (0.9)^2 U_0$$

$$\text{Therefore for 10 bounces, } U_{10} = (0.9)^{10} U_0$$

$$h_{10} = (0.9)^{10} h_0 = 0.349(2.00\text{m}) = 0.697\text{m}$$

6. On a surface, a block with mass of 25 kg slides with a speed of 12 m/s. It hits an ideal spring and bounces off with the original speed. How much work was done by the spring on the block?

- A) 0.00 J  
B) 3600 J  
C) 1800 J  
D) 300 J
- E) 600 J  
F) 150 J  
G) 2400 J  
H) 1200 J

$$W = K_f - K_0 = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2 = 0$$

No work done on mass. Work on the mass

has opposite signs: going in (-) or coming off (+).

7. A catapult accelerates an aircraft with a weight of  $2.45 \times 10^5$  N, to 100 m/s in 2 seconds. How much work was done on the aircraft by the catapult?

- A)  $1.25 \times 10^7$  J  
B)  $1.25 \times 10^6$  J  
C)  $2.50 \times 10^6$  J  
D)  $2.50 \times 10^7$  J
- E)  $2.50 \times 10^8$  J  
F)  $2.50 \times 10^9$  J  
G)  $1.25 \times 10^8$  J  
H) 0.00 J

$$mg = 2.45 \times 10^5 \text{ N}, \quad m = (2.45 \times 10^5) / 9.81 \text{ kg} = 2.49 \times 10^4 \text{ kg}$$

$$W = K_f - K_i = \frac{1}{2}mv_f^2 - 0 = 0.5(2.49 \times 10^4)(100)^2 \text{ J}$$

$$= 1.25 \times 10^8 \text{ J}$$

8. Acting on an object with mass,  $m = 55\text{kg}$ , are two forces:  $F_1 = 65\text{N}$ ,  $\theta = 59^\circ$ , and  $F_2 = 35\text{N}$ ,  $\phi = 32^\circ$ , as shown in the diagram. What is the magnitude of the object's acceleration?

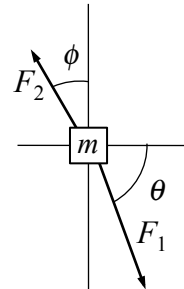
- A)  $0.254 \text{ m/s}^2$   
B)  $0.345 \text{ m/s}^2$   
C)  $0.422 \text{ m/s}^2$   
D)  $0.546 \text{ m/s}^2$
- E)  $0.595 \text{ m/s}^2$   
F)  $0.635 \text{ m/s}^2$   
G)  $0.695 \text{ m/s}^2$   
H)  $0.715 \text{ m/s}^2$

$$F_x = F_1 \cos 59^\circ - F_2 \sin 32^\circ = 14.93\text{N}$$

$$F_y = -F_1 \sin 59^\circ + F_2 \cos 32^\circ = -26.03\text{N}$$

$$F = \sqrt{F_x^2 + F_y^2} = 30.01\text{N}$$

$$a = F / m = (30.01 / 55)\text{m/s}^2 = 0.546\text{m/s}^2$$



9. A traveler pulls on a suitcase strap at an angle of  $36.0^\circ$  above the horizontal. The strap does 908 J of work moving the suitcase a horizontal distance of 15.0 m. What is the tension in the strap?

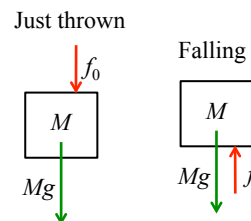
- A) 35.6 N  
B) 103 N  
C)  $1.01 \times 10^5$  N  
D)  $8.01 \times 10^3$  N
- E) 74.8 N  
F)  $1.01 \times 10^4$  N  
G)  $8.01 \times 10^4$  N  
H) 734 N

$$W = F(\cos \theta)\Delta x. \quad \text{Tension } F$$

$$F = W / (\cos \theta)\Delta x = 908 / [(15.0)\cos 36^\circ] \text{ N} = 74.8 \text{ N}$$

10. Suppose the force of wind resistance (friction) is proportional to the speed of an object and in the direction opposite to the object's velocity. From a platform 10 m above the ground an object is thrown upward and it eventually falls into a hole in the ground 10 m deep. By drawing free-body diagrams determine when the *magnitude* of the acceleration of the object is the highest.

The force of friction is in the direction of the gravitational force only on the way up, and is largest when the speed is the greatest, and that is when it is just thrown.



- A) When the object is just released.
- B) When the object reaches the highest point.
- C) When moving downward the object passes the starting height.
- D) When the object is just about to hit the bottom of the hole.
- E) When the object is just released and when moving downward it passes its starting height.
- F) When the object has a speed that is no longer increasing.
- G) When the speed of the object obtains its original speed.
- H) When the object reaches its terminal velocity.

The dependence of the frictional force on the speed was not sufficiently emphasized in the problem. All students will get credit for the problem.

11. Consider the head on collision of a Garbage Truck with a Chevy Volt without any rebound. Which vehicle experiences the largest force? The largest magnitude of force is always experienced by the vehicle with the

Newton's 3rd law: At the point of contact, the forces have equal magnitudes and opposite directions on the two objects.

- |                           |  |
|---------------------------|--|
| A) largest initial speed  | E) largest initial momentum                                |
| B) smallest initial speed | F) smallest initial momentum                               |
| C) largest mass           | G) the most initial energy                                 |
| D) smallest mass          | H) ; both vehicles experience the same magnitude of force. |

12. A golf ball of mass 0.050 kg is at rest on the tee. It has a horizontal velocity of 102 m/s immediately after being struck. If the club and the ball were in contact for 0.81 ms, what was the average force exerted on the ball?

- |            |            |
|------------|------------|
| A) 5.30 kN | E) 6.30 kN |
| B) 7.10 kN | F) 7.40 kN |
| C) 5.60 kN | G) 4.70 kN |
| D) 4.90 kN | H) 4.50 kN |

Impulse causes the change in momentum in time,  $\Delta t = 0.81 \times 10^{-3}$  s

$$\Delta p = mv_f - 0 = (0.050)(102) \text{ Ns} = 5.10 \text{ Ns}$$

$$\text{Impulse: } F \Delta t = \Delta p; \quad F = \Delta p / \Delta t = (5.10 / 0.81 \times 10^{-3}) \text{ N} = 6.30 \text{ kN}$$

13. An object experiences a force vs. time as given by the figure. What is the momentum change experienced by the object?

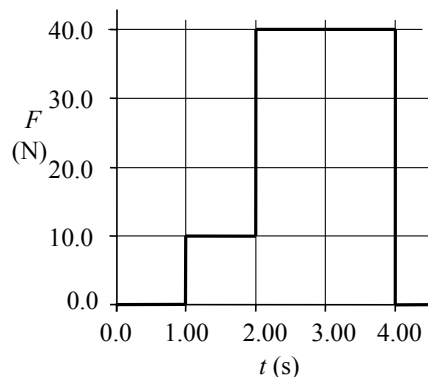
- |                |                                    |
|----------------|------------------------------------|
| A) 90.0 kg m/s | E) 25.0 kg m/s                     |
| B) 75.0 kg m/s | F) 160 kg m/s                      |
| C) 60.0 kg m/s | G) 9.00 kg m/s                     |
| D) 50.0 kg m/s | H) mass is need to know $\Delta p$ |

$$\Delta p = F_{\text{Ave}} \Delta t, \text{ or area under } F \text{ vs. } t \text{ curve.}$$

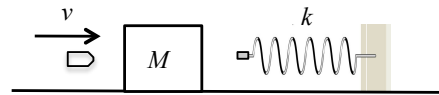
$$F_{\text{Ave}} = 10.0 \text{ N for 1s, and } 40.0 \text{ N for 2s}$$

$$= [(10.0 \text{ N}) + 2(40.0 \text{ N})] / 3 = 30.0 \text{ N}$$

$$\Delta p = F_{\text{Ave}} \Delta t = (30 \text{ N})(3 \text{ s}) = 90 \text{ Ns} = 90 \text{ kg m/s}$$



14. A bullet with a mass  $m = 8.00\text{g}$ , is shot into a block with a mass,  $M = 4.00\text{ kg}$ . The bullet stops in the block. The block and bullet travel on a frictionless surface then compress an ideal spring (spring constant  $k = 2500\text{N/m}$ ) by  $3.70\text{ cm}$ . What is the initial speed of the bullet?



- A) 563 m/s  
B) 423 m/s  
C) 493 m/s  
D) 533 m/s
- E) 463 m/s  
F) 333 m/s  
G) 593 m/s  
H) 393 m/s

$p_i = mv_i$ ,  $p_f = (m + M)v_f$ ,  $p$  conserved for bullet & block

$$p_i = p_f \rightarrow v_f = [m / (m + M)]v_i$$

Therefore, block  $K = \frac{1}{2}(m + M)v_f^2 = \frac{1}{2}[m^2 / (m + M)]v_i^2$

Compressed spring  $U_f = \frac{1}{2}kx^2 = (0.5)(2500)(0.037)^2 \text{ J} = 1.711 \text{ J}$

Energy conserved:  $K + U_i = K_f + U_f$  with  $U_i = 0$ , and  $K_f = 0$

$$\frac{1}{2}[m^2 / (m + M)]v_i^2 = 1.711 \text{ J}$$

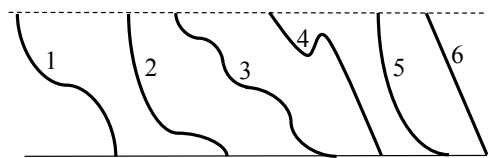
$$v_i = \sqrt{\frac{2(1.711)(.008 + 4.00)}{(.008)^2}} \text{ m/s} = 463 \text{ m/s}$$

15. Consider the energy transfers that take place as you use a slingshot to shoot a rock upward against drag of the air. The rock rises to a peak height and then falls, finally hitting the ground and stops without bouncing. Which statement below (if none chose H) is incorrect regarding these energy transfers?

- A) Part of the chemical energy in your muscles becomes potential energy of a stretched elastic.  
B) Elastic potential energy is transformed to kinetic energy by relaxation of the stretched elastic.  
C) The kinetic energy of the rock is transformed into gravitational potential energy in the flight.  
D) Air friction prevents the complete transfer of kinetic energy to gravitational potential energy.  
E) At the peak height all the rock's mechanical energy is in gravitational potential energy.  
F) The gravitational potential energy at the peak height is completely transferred to kinetic energy of the rock just before it hits the ground.  
G) The rock hits the ground and loses its kinetic energy to distortion of the ground and some heat and sound energy.  
H) All of the above statements are correct.

F) is incorrect because the rock loses energy by air friction (drag) while falling.

16. A ball can be rolled down one of 6 ramps, each with the same starting and ending height, as shown in the figure. Neglecting friction, which ramp(s) will lead to the largest speed for the ball at the bottom of the ramp?



- A) 1  
B) 2  
C) 3  
D) 4
- E) 5  
F) 6  
G) All ramps lead to the same speed at the bottom.  
H) All ramps except ramp 4, lead to the same speed at the bottom.

Without friction, the potential energy of the ball is completely transferred to its kinetic energy at the bottom of each ramp.