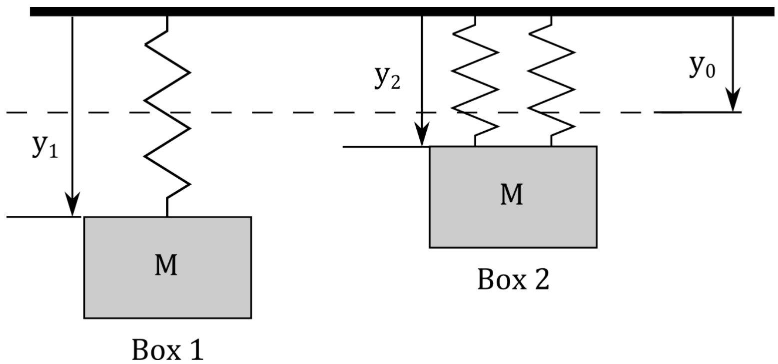
The next three questions pertain to the situation described below.



Two identical boxes (mass $M = 7kg$) hang from the ceiling. One box is attached to the ceiling with one spring, while the other box is attached with two springs. All three springs have the same spring constant k and the same unstretched length $y_0 = 0.14m$. The top of Box 1 is $y_1 = 0.7m$ away from the ceiling while the top of Box 2 is y_2 meters from the ceiling.

1) What is the value of the spring constant k?

a. k = 122.6 N/m
b. k = 98.1 N/m
c. k = 490.5 N/m
d. k = 245.3 N/m
e. k = 981 N/m

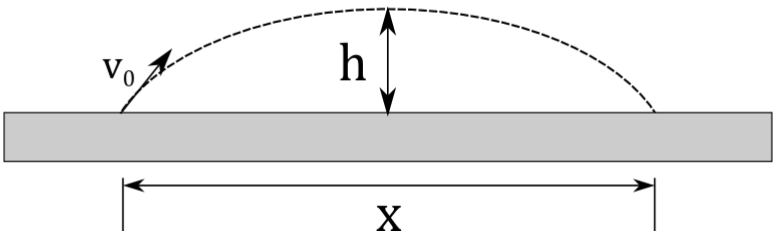
2) What is y_2, the distance from the top of Box 2 to the ceiling?

a. $y_2 = (y_1 + y_0)/2$
b. $y_2 = y_1/2$
c. $y_2 = (y_1 - y_0)/2$
d. $y_2 = (2y_1 - y_0)$
e. $y_2 = (y_1 + 2y_0)$

3) Suppose the mass of Box 1 is changed to M_{new}, and that after this change you observe that both boxes are the same distance from the ceiling. How does M_{new} compare to M?

a. $M_{new} = M/2$
b. $M_{new} = M/4$
c. This can't be determined without knowing the spring constant.

The next four questions pertain to the situation described below.



A football is kicked across a level field. The ball spends 6.3 seconds in the air and lands a distance $X = 48$ meters from the point where it was kicked. The initial speed of the ball is V_0. You should ignore air resistance.

4) What is the speed of the ball at the top of its trajectory?

a. v = 61.8 m/s
b. v = 30.9 m/s
c. There is not enough information given to determine this.
d. v = 4.89 m/s
e. v = 7.62 m/s

5) What is the maximum height reached by the ball?

a. h = 24 m
b. h = 16 m
c. h = 48.67 m
d. h = 97.34 m
e. h = 12 m

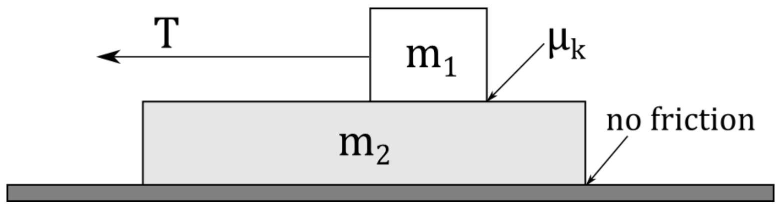
6) After the kick, but before the ball hits the ground, which of the following statements best describes the acceleration vector of the ball?

a. It always points downward.
b. It points upward before the ball reaches its maximum height, then downward.
c. It always points toward the right.

7) Suppose the ball was kicked with the same initial angle but with twice the initial speed. How far from the kicker would the ball land?

a. $X_{new} = 4X$
b. $X_{new} = 2X$
c. $X_{new} = \sqrt{2}X$

The next three questions pertain to the situation described below.



A box of mass m_1 = 3 kg is being pulled by a horizontal string with tension T as shown. It moves to the left with a constant velocity across the top of a second box having a mass of m_2 = 8 kg. The kinetic coefficient of friction between the upper box and the lower box is μ_k = 0.5. There is no friction between the lower box and the horizontal floor, and the lower box accelerates to the left. Assume that the upper box is moving faster that the lower box.

8) Which of the following statements best describes the net force acting on the upper box?

a. It points to the left.
b. It points to the right.
c. It is zero.

9) Which of the following statements best describes the force of friction acting on the lower box?

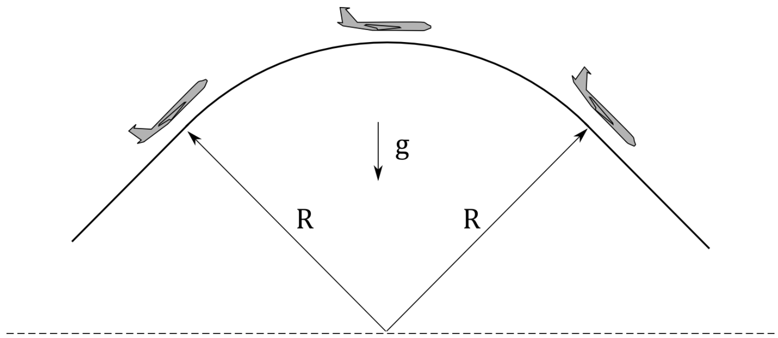
a. It points to the right.
b. It points to the left.
c. It is zero.

10) What is the magnitude of the acceleration of the lower box ?

a. a = 1.8 m/s^2
b. a = 0.9 m/s^2
c. a = 4.9 m/s^2
d. a = 13.1 m/s^2
e. a = 1.3 m/s^2

The next two questions pertain to the situation described below.

An aircraft climbs and then descends, following a vertical circular path of radius R = 3308 m as shown. At the top of its trajectory the speed of the aircraft is constant and is equal to 156 m/s. The mass of the pilot is 80 kg.



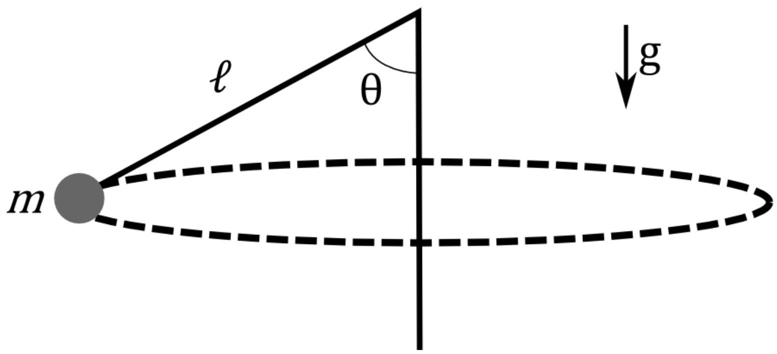
11) At the top of the trajectory, what is the magnitude of the force exerted on the pilot by his seat ?

a. F_{seat} = 1373 N
b. F_{seat} = 7.36 N
c. F_{seat} = 491 N
d. F_{seat} = 784.8 N
e. F_{seat} = 196.26 N

12) If both the radius of the circular trajectory and the speed of the aircraft were reduced by a factor of two, how would the force exerted on the pilot change from the answer you found above ?

a. It would decrease
b. It would increase
c. It would stay the same

The next three questions pertain to the situation described below.



A child is playing with a new toy that consists of a ball $m = 0.87$ kg tied to the end of a string of length $\ell = 0.3$ m. The child swings the toy above her head so that it moves with uniform circular motion in the horizontal plane. The string makes an angle of 63° with respect to the vertical arm of the child.

13) What is the tension in the string?

a. T = 18.8 N
b. T = 9.58 N
c. T = 4.35 N
d. T = 55.83 N
e. T = 8.53 N

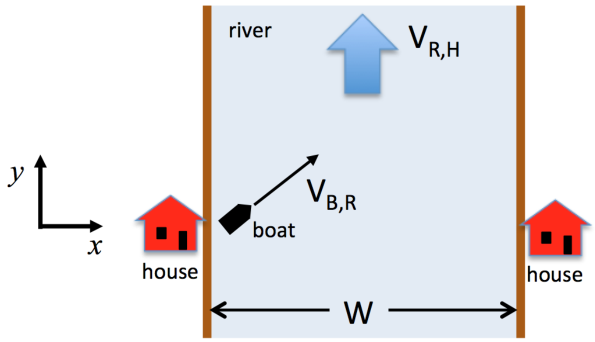
14) Say the tension in the string in the original problem is T. Suppose the ball is now swung in such a way that the angle of the string is decreased. What is the new tension in the string?

a. $T_{new} < T$
b. $T_{new} > T$
c. $T_{new} = T$

15) Say the speed of the ball in the original problem is V_0. Suppose we increase mass of the ball but keep the length of the string the same. If we want the angle that the string makes with the vertical to be the same as in the original problem, what would the new speed of the ball have to be?

a. $V_{new} > V_0$
b. $V_{new} < V_0$
c. $V_{new} = V_0$

The next three questions pertain to the situation described below.



Two houses are located on opposite sides of a river as shown. The width of the river is W = 247 m, and the river flows in the +y direction with speed $V_{R,H}$ = 1.3 m/s relative to the houses. A boat sets off from the left house, moving with velocity $V_{B,R}$ relative to the river. The x-component of $V_{B,R}$ is 2.1 m/s and the y-component of $V_{B,R}$ is 3.1 m/s.

16) What is the speed of the boat as measured in the reference frame of the houses?

a. $|V_{B,H}|$ = 4.88 m/s
b. $|V_{B,H}|$ = 3.74 m/s
c. $|V_{B,H}|$ = 2.77 m/s
d. $|V_{B,H}|$ = 2.47 m/s
e. $|V_{B,H}|$ = 4.4 m/s

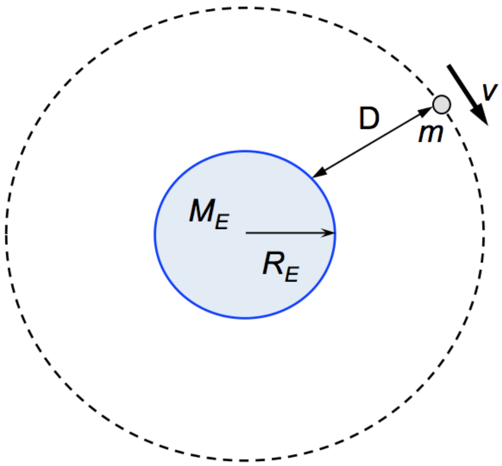
17) When the boat reaches the other side of the river, how far is it from the nearest house?

a. 517.52 m
b. 211.71 m
c. 364.62 m
d. 167.32 m
e. 152.9 m

18) Say the time it takes the boat to get to the other side in the above scenario is T_0. Now suppose the driver of the boat steers in such a way that the boat moves along the x-axis, directly from the house on the left to the house on the right. If the speed of the boat relative to the water is the same as in the original problem, compare the time it takes the boat to get across the river in the new case, T_{new}, to T_0.

a. $T_{new} < T_0$
b. $T_{new} = T_0$
c. $T_{new} > T_0$

The next two questions pertain to the situation described below.



A satellite is put into a circular orbit around the earth. The satellite has a mass of $m = 225$ kg. The radius of the Earth is $R_E = 6.37 \times 10^6$ m, the mass of the Earth is $M_E = 5.97 \times 10^{24}$ kg, and the universal gravitational constant is $G = 6.67 \times 10^{-11}\ Nm^2/kg^2$.

19) If the speed of the satellite relative to the center of the earth is V = 6158.22 m/s, what distance D above the Earth's surface is it orbiting ?

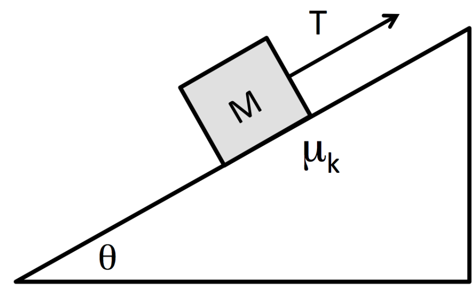
a. D = 4.13×10^6 m
b. D = 2.478×10^6 m
c. D = 1.687×10^7 m
d. D = 3.304×10^6 m
e. D = 2.891×10^6 m

20) If we want to reduce the speed of the satellite relative to the center of the earth, how should we change the radius of the orbit?

a. We should increase the radius of the orbit.
b. We should decrease the radius of the orbit.
c. The speed of the satellite does not depend on the radius of the orbit.

The next four questions pertain to the situation described below.

A block of mass m = 1.8 kg is being pulled up an inclined plane at constant velocity by a string having tension T. The angle of the inclined plane is $\theta = 34$ degrees above the horizontal, as shown in the diagram. The coefficient of kinetic friction between the block and the surface of the inclined plane is $\mu_K = 0.25$.



21) The magnitude of the normal force acting on the block is

a. Less than the weight of the block.
b. Equal to the weight of the block.
c. Greater than the weight of the block.

22) What is the tension in the string?

a. T = 13.5 N
b. T = 9.9 N
c. T = 3.7 N
d. T = 4.4 N
e. T = 14.3 N

23) The string is now cut and the block slides down the inclined plane. What is the magnitude of the acceleration of the block?

a. 3.5 m/s^2
b. 5.5 m/s^2
c. 7.5 m/s^2
d. 6.8 m/s^2
e. 8.1 m/s^2

24) Suppose the mass of the block is increased but the angle of the inclined plane and the coefficient of friction remains the same as above. How will the magnitude of the acceleration of the block sliding down the plane change compared to the previous question?

a. It will stay the same.
b. In will increase.
c. It will decrease.