PHYS 1410: College Physics I — Spring 2009

Exam II: Chapters 04-06

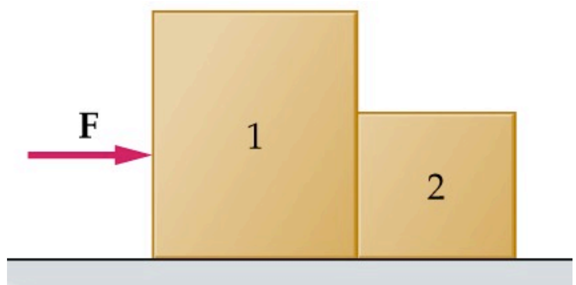
1. According to Newton's first law of motion,
   A) the state of motion of an object cannot be changed.
   B) for an object to remain at rest or in motion, a force is required.
   C) objects in motion will inevitably slow down, eventually coming to rest.
   D) objects at rest will remain at rest unless an unbalanced external force is applied.
   E) any scientific idea proposed or advocated by that poseur Leibniz is automatically wrong.

2. An object's **inertia**
   A) is directly proportional to its mass: the more mass an object has, the more inertia it has.
   B) is inversely proportional to its weight: the more an object weighs, the less its inertia.
   C) is inversely proportional to its force: the harder you push on an object, the less inertia it has.
   D) is directly proportional to its acceleration: the greater the acceleration of an object, the more inertia it has.
   E) is inversely proportional to its resistance to a change in its state of motion: less inertia means it is more difficult to change an object's motion.

3. On July 20, 1969, Neil Armstrong became the first man to walk on the moon.
   A) His weight remained the same on Earth, in space, and on the moon.
   B) His mass remained the same on Earth, in space, and on the moon.
   C) While in space, he had no mass.
   D) While on the moon, he had no weight.
   E) He had less mass on the moon than on Earth.

4. According to **Newton's second law** of motion,
   A) an object will experience acceleration only in the absence of an unbalanced force.
   B) an object will experience a force directly proportional to the amount of applied mass.
   C) an object will experience a mass directly proportional to the amount of applied acceleration.
   D) an object will experience an acceleration directly proportional to the amount of applied force.
   E) Leibniz is a scene–stealing, calculus–cribbing, wig–wearing, French–speaking, insect–eating poltroon!

Two boxes are at rest on the floor. The coefficient of static friction μ_s = **0.4** and kinetic friction μ_k = **0.3** between the boxes and the floor. The boxes are not attached in any way (no tape/glue/staples). Box 1 has a mass m_1 = **8 kg**, and box 2 has a mass m_2 = **3 kg**. Answer questions 5–11 using this information.



5. A force **F=50N** is applied as shown to box 1. Why does box 2 move?
   A) The force of static friction causes box 2 to move.
   B) The force of *kinetic* friction causes box 2 to move.
   C) The normal force exerted on box 2 by box 1 creates the motion of box 2.
   D) The applied force F causes box 2 to move. Just because it is not directly applied to box 2 does not mean it is not acting directly on box 2.
   E) Because it *is* attached to box 1. It *has* to be, or it could not move. Maybe there are magnets inside the boxes that we just can't see.

6. Once the boxes are in motion, you suddenly reach out and grab box 1, stopping it almost instantly.
   A) Box 2 stops simultaneously with box 1.
   B) Box 2 continues to move forward at the same unchanging speed.
   C) Box 2 moves forward, but speeds up with acceleration $a = \mu_k g$.
   D) Box 2 continues forward, but slows down and eventually stops, just not as fast as box 1 stopped.

7. What *minimum* horizontal force F_1 must be applied to box 1 it to make it move (independently, not touching box 2)? Express your answer to the nearest integer. **$F_1 = f_s = \mu_s N = \mu_s(mg) = 0.4(8kg)(9.8m/s^2) = 31.4N$**

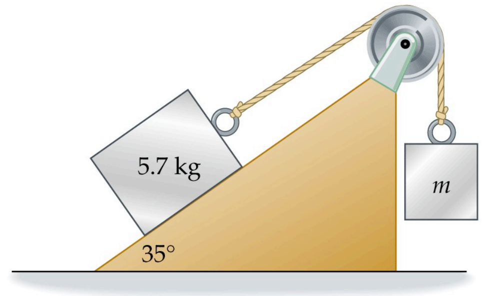
8. What minimum horizontal force F_2 must be applied to box 2 to make *it* move ?
   A) The same amount of force as calculated for the 8 kg box.
   B) Box 2 will require a greater force than box 1.
   C) Box 2 will require less force than box 1.

9. When a horizontal force **F = +20N** is applied to box 1, what force of static friction f_s acts on the box?
   A) $f_s = -31N$
   B) $f_s = -20N$
   C) $f_s = 0N$
   D) $f_s = +20N$
   E) $f_s = +31N$

10. True or **false**: When both boxes are in motion (independently), the force of kinetic friction f_k will be the same on each.

11. *In the absence of friction*, the **same force** applied to each box (independently, with boxes no longer touching each other)
A) will create the same acceleration in both boxes.
B) will create less acceleration in box 1.
C) will create less acceleration in box 2.
D) will not cause either box to move.
E) will cause both boxes to move with the same constant velocity.

12. The block on the right has a mass ***M*** **= 5.7 kg**. The **frictionless** incline is angled at θ = **35°**. What is the **normal force** exerted on the block by the incline? **N = (mg)cosθ =(5.7kg)(9.8m/s²)cos35° = 45.8N**



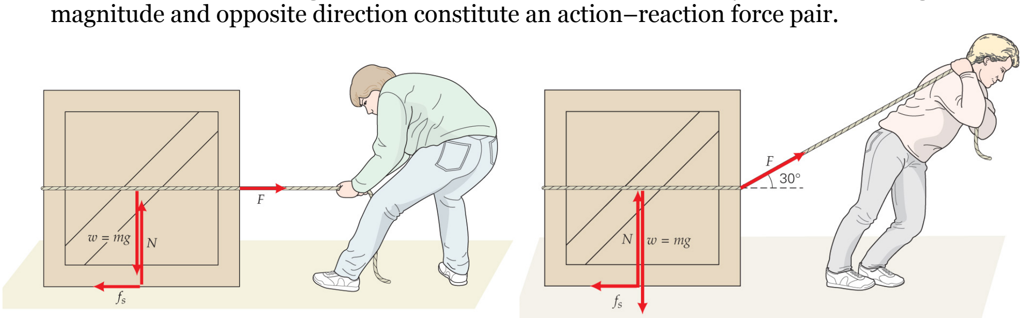
13. If you attach a 4kg mass *m* to the cord as shown and release the system from rest, what motion will result?
A) None. The system will be in equilibrium.
B) Mass *m* falls downward, pulling *M* up the ramp.
C) Mass *m* rises vertically while *M* slides up the ramp.
D) Mass *M* slides down the ramp, pulling *m* up vertically.
E) Mass *M* slides down the ramp while *m* falls to the ground.

14. Assume now that the incline above is adjustable, and that it is *not* frictionless. We have removed the cord and the pulley, so that *M* is no longer attached to any other masses. As the incline is gradually raised from 0° to 20°, the block remains **stationary**. The **force of static friction** on the block *M*
A) remains constant as the angle increases: $f_s = \mu_s N$, where N = Mg, the weight of the block.
B) remains constant as the angle increases: $f_s = \mu_s N$, but N = (Mg)cos(20°).
C) increases steadily as the board is raised: f_s must balance the component of the weight that is parallel to the board. As the angle increases, the parallel component (Mgsinθ) increases, so more friction is required.
D) decreases steadily as the board is raised. When the board gets to 20°, the static friction is at a minimum (zero) and the force of kinetic friction takes over. Because $f_k < f_s$, the block starts to slide down the incline.

15. As you carefully continue to raise the incline, the block just starts to slide when the angle reaches θ = 40°. The **coefficient of kinetic friction μ_k**
A) must be exactly tan(40°) = 0.84. This makes sense, because μ_k must be larger than the static coefficient.
B) must be larger than the static coefficient, but we can't know for sure that it is exactly equal to 0.84.
C) must be exactly the same as the static coefficient, because they are the same by definition.
D) must be less than μ_s, but we don't know what μ_s is.
E) must be less than μ_s, and we know that μ_s =tan(40°), so μ_k < 0.84.

16. Your calculator rests on top of your physics book. You push the book across the table, and the calculator moves right along with the book. This is because
A) the force you applied to the book is applied directly to the calculator as well.
B) the normal force on the calculator because of the book causes it to accelerate.
C) the force of kinetic friction slows the book down, but speeds the calculator up.
D) the force of static friction between the objects actually causes the calculator's motion.
E) it has less mass, thus less inertia than the book. This means it does not require a force to move it.

17. True or **false**: According to **Newton's third law** of motion, any two forces acting on the same object that have the same magnitude and opposite direction constitute an action–reaction force pair.



George-Michael (on the left) pulls the crate **horizontally**, as shown. Maeby (on the right) pulls her crate with the **same magnitude force**, but at an angle of **30°**. Assume that both crates have the **same mass**, and are pulled across the same floor (so the coefficients of friction μ_s and μ_k are the same).

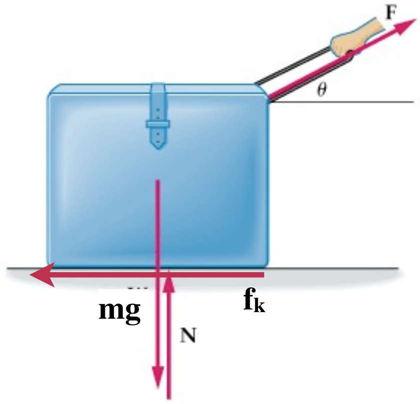
18. The normal force is greater on which crate?
A) George-Michael's crate.
B) Maeby's crate.
C) The normal force is exactly the same on both crates: N = mg.

19. Which crate experiences a smaller force of kinetic friction f_k?
A) George-Michael's crate.
B) Maeby's crate.
C) The crates have the same weight, so they must have the same frictional force.

20. True or **false**: If both George-Michael and Maeby pull their respective crates the same distance x across the floor, they will do the same amount of work.

21.

22. When **negative work** is done by a force on an object,
 A) the kinetic energy is zero, and becomes negative as more negative work is done.
 B) the kinetic energy of the object is negative, and increasing (getting more negative).
 C) the kinetic energy of the object is negative, and decreasing (approaches zero).
 D) the kinetic energy of the object is positive, and increasing (getting more positive).
 E) the kinetic energy of the object is positive, and decreasing (approaches zero).

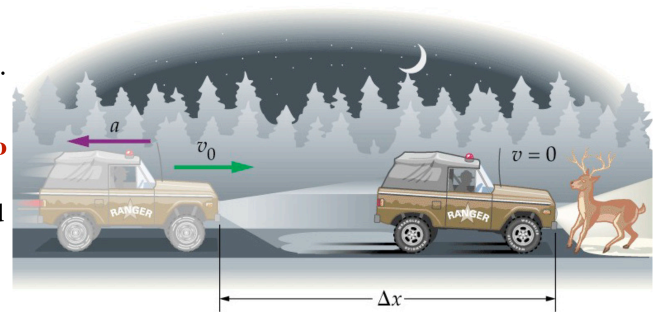


23. A woman is pulling her case across the floor as shown. The case moves with a **constant velocity** through a horizontal distance x (to the right). The **work** done on the case by the force of **kinetic friction** is
 A) negative. B) zero. C) positive.

24. The **work** done on the case by the **applied force F**
 A) is negative. The net work done on the case by friction and the applied force is negative. This means that the case *cannot* be moving to the right; it *has* to be moving to the left!
 B) is negative. Because the work done by friction is positive, the net work done on the case is zero. This means that the case cannot be moving at all; it must be at rest.
 C) is positive. The amount of work done by the applied force is greater than the work done by friction on the case. The net work is positive, which it has to be if the case moves forward (K is positive!).
 D) is positive. The amount of positive work done matches the amount of negative work done by friction, so no net work is done. The case moves, but its kinetic energy remains constant.
 E) is zero. Because the direction of the force and the displacement are not the same, no work can be done. The applied force F does not cause or change the motion of the case in any way.

25. The amount of **work** W done on the case by the force of **gravity** is
 A) +(mg)x. B) −(mg)x. C) +(mg)h. D) −(mg)h. **E) zero.**

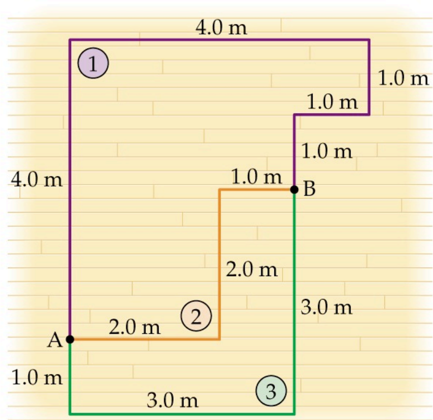
26. How much **net** work is done on the case above?
 A) The net force is negative, so the net work done is negative.
 B) The net force is positive, so the net work done is positive.
 C) The net force is down, so the net work done is positive.
 D) The net force is up, so the net work done is negative.
 E) The net force is zero, so the net work done is also zero.



27. The park ranger is driving 20 mph. When he hits the gas and accelerates up to 40 mph, he has
 A) halved the kinetic energy of the Range Rover.
 B) doubled the kinetic energy of the Range Rover.
 C) quadrupled the kinetic energy of the Range Rover.
 D) not changed the kinetic energy of the Range Rover.

28. Suddenly he sees that 8-point buck in the road. His stopping distance at 20mph is only 40 feet. But since he is moving at 40 mph, how much stopping distance does he need?
 A) 10 feet. B) 20 feet. C) 40 feet. D) 80 feet. **E) 160 feet.**

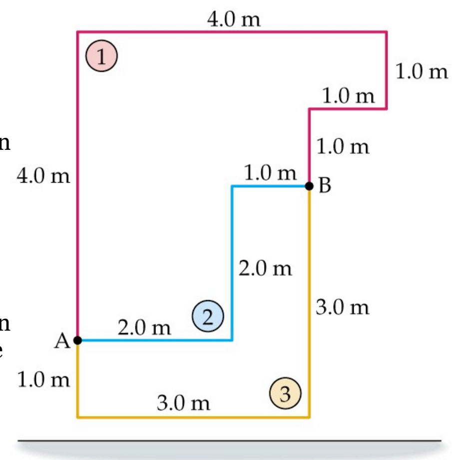
29. He does not hit the deer, but unfortunately a night-flying insect slams into his windshield.
 A) The truck obviously exerts more force on the bug than the bug exerts on the truck.
 B) The bug exerts more force on the truck than the truck exerts on the bug. Not exactly obvious, but true.
 C) Force on the bug is exactly the same as the force on the truck, in the opposite direction. Newton #3.
 D) Clearly the bug gets squashed. Whatever Newton #3 says, you can't argue with the splatted bug. I am sticking with my original answer, and the truck *has* to exert more force on the bug.



Three different horizontal paths across a wooden floor are shown on the left from point A to point B.

30. True or **false**: The force of kinetic friction will do the same amount of work on an object, whether it follows path 1, 2, or 3.

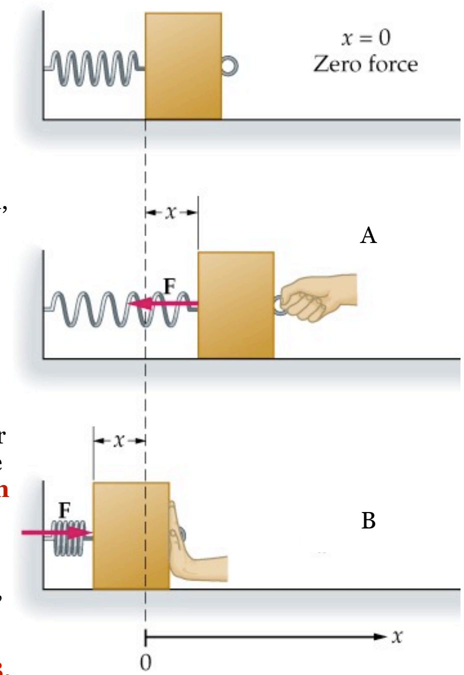
31. True or **false**: The force of kinetic friction can do either positive or negative work on an object, depending on the direction it is traveling and the direction you label as positive on your coordinate system.



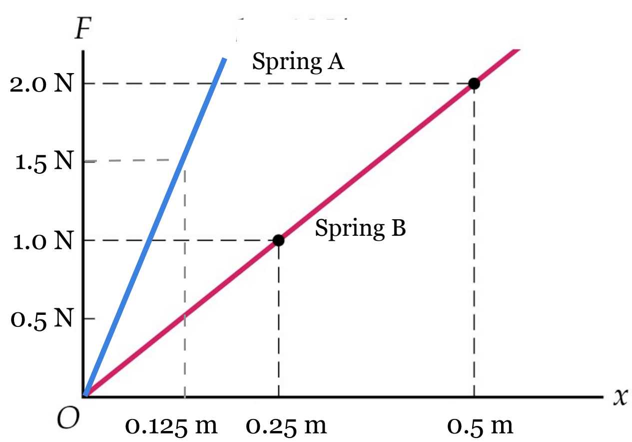
Three different vertical paths in the air are shown on the right from point A to point B.

32. **True** or false: Gravity will do the same amount of work on an object, whether it follows path 1, 2, or 3.

33. In position A, the spring shown has been stretched by an amount x from its original rest length. In position B, the same spring has been compressed by an equal amount x from its rest length.
A) The magnitude of the spring force F_A is greater than F_B.
B) The magnitude of the spring force F_B is greater than F_A.
C) The magnitude of the spring force $F_A = F_B$.



34. Two different springs were tested by applying the same amount of force to each, and measuring the amount of stretch (position relative to the unstretched spring). The results are plotted below.
A) Spring A is stiffer than B: $k_A > k_B$.
B) Spring B is stiffer than A: $k_B > k_A$.
C) The springs are identical: $k_A = k_B$.
D) No conclusion can be drawn about k_A or k_B because the graph has no scale or units.



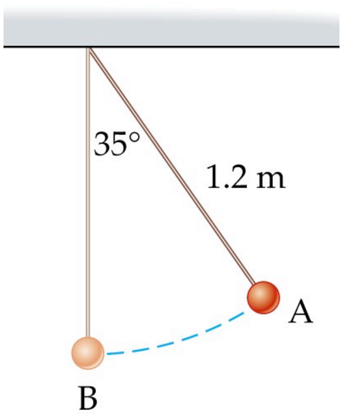
35. What is k_B? Answer to the nearest whole integer. **k_B = 4N/m**

36. When you apply the same amount of force to each spring,
A) spring A will stretch less than spring B.
B) spring B will stretch less than spring A.
C) both springs will stretch by the same amount.
D) neither spring will stretch by any amount.
E) you cannot accurately predict what either spring will do.

37. The potential energy stored by a spring is always positive.
A) True; either the spring is storing energy or it isn't.
B) False; like gravitational PE, it can be either positive or negative.

38. The potential energy due to gravity is always positive.
A) True; either an object is at the reference level (U = 0) or it isn't (U > 0).
B) False; depending on where you establish a reference level, you may have positive or negative potential energy.

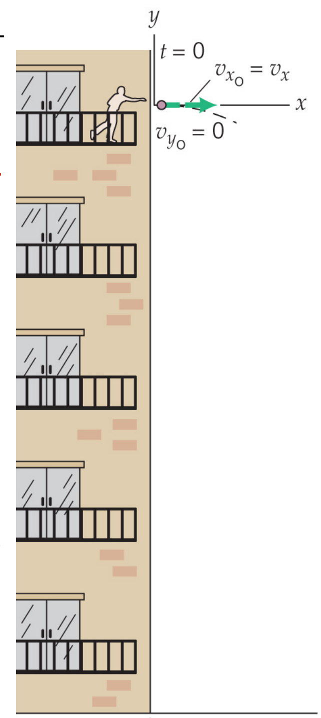
39. In a non–conservative system, energy is lost. Where does it go?
A) Nowhere; the energy can't really be lost, the system still has as much energy as it ever did. The "lost" energy is probably just a conversion of potential to kinetic or kinetic to potential.
B) The lost energy no longer exists. Eventually *all* the energy will be gone: gone from the system, gone from the universe. Thankfully we don't have to worry about this problem for billions of years yet.
C) The system has less energy, but the missing energy had to go somewhere. For example, if friction does work on the system, the energy is dissipated as heat. The energy has not disappeared from the universe.



A pendulum is pulled back to an angle of 35° and released from rest. The pendulum at point A is 22cm above the pendulum at point B. Let point B be the reference level h = 0.

40. When the pendulum swings down to a point between A and B, where it is 11 cm above point B,
    A) it will have all kinetic and no potential energy.
    B) it will have all potential and no kinetic energy.
    C) it will have twice as much potential energy as kinetic energy.
    D) it will have twice as much kinetic energy as potential energy.
    E) it will have equal amounts of kinetic and potential energy.

41. As the pendulum moves through point B, it will continue to swing to the left. How high will the pendulum rise?
    A) Until the pendulum cord is horizontal, or the pendulum bob hits the ceiling.
    B) Until it is 1.2m above point B.
    C) Until the pendulum is 22cm below the ceiling.
    D)Until the cord makes an angle of 35° with the vertical.
    E) There is no way to predict the behavior of the pendulum once it passes point B.



42. A boy throws a baseball as shown. It has a mass m = 0.200kg and an initial horizontal velocity v_{ox} = 10 m/s. What happens to the momentum of the compact as it falls for a time t?
    A) Nothing. The initial momentum $\mathbf{p_o}$ = (0.200kg)(10m/s)î remains constant.
    B) The momentum increases with time t: **p** = [(0.200)(10 + 9.8t)kg·m/s]**î**.
    C) The momentum decreases with time t: **p** = [(0.200kg)(10 – 9.8t) kg·m/s]**î**.
    D) The horizontal component remains constant: p_x = 2kg·m/s→, while the vertical component increases in the negative direction: p_y = (0.200)(9.8t)kg·m/s↓.
    E) The horizontal component of the momentum increases in the positive direction: p_x = [(0.200)(10 + 9.8t)kg·m/s]→, while the vertical component decreases in the negative direction: p_y = [(0.200kg)(10 – 9.8t) kg·m/s]↓.

43. True or **false**: An object with zero momentum can have non–zero kinetic energy.

44. True or **false**: An object that has negative momentum must have negative kinetic energy.

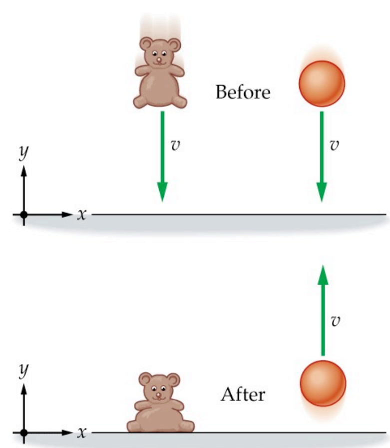
45. **True** or false: Two objects having the same kinetic energy may have different momenta.

46. **True** or false: Two objects having the same momentum may have different kinetic energy.

47. An unlucky fly, cursed by the numbers 4, 8, 15, 16, 23, and 42 collides with the windshield of a VW minibus careening wildly down a hill. Compare the impulse on the fly to the impulse on the VW minibus.
    A) The impulse on the fly is greater than the impulse on the VW.
    B) The impulse on the VW is greater than the impulse on the fly.
    C) The impulse on the fly is equal and opposite to the impulse on the VW.

48. Compare the change in velocity of the fly to the change in velocity of the minibus.
    A) The fly experiences a greater change in velocity.
    B) The VW experiences a greater change in velocity.
    C) The change in the velocity of the fly is equal and opposite to the change in the velocity of the VW.

A Toy Ball and a Beanie Baby have the same size and mass. They are simultaneously released from rest **50cm** above the ground. The ball rebounds to a height of **30cm**, while the Beanie hits the ground and **sticks**. It does not bounce at all. Answer each of the following questions **T** for **true** or **F** for **false**.



49. True or **false**: When Beanie Baby and the earth collide, system momentum is lost.

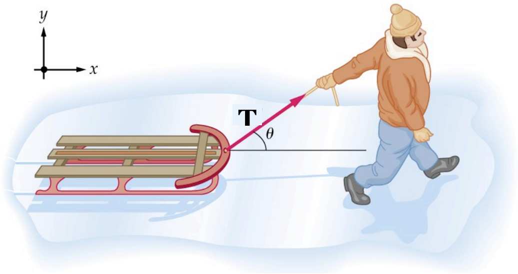
50. **True** or false: Toy Ball experiences a greater change in momentum than Beanie Baby.

51. **True** or false: When Toy Ball collides with the earth, the earth gains momentum.

52. True or **false**: Both collisions conserve energy.

53. **True** or false: The coefficient of restitution for the Beanie Baby collision is e = 0.

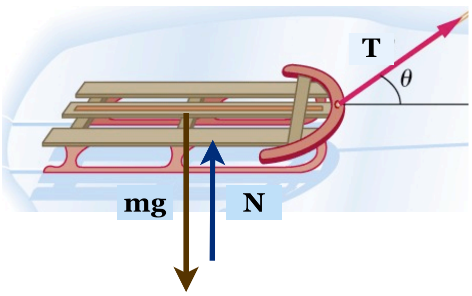
Problem 1: Homework Problem 4.66



The boy is pulling his sled across the ice as shown. The sled has a mass of **8kg**. The boy is pulling his rope at an angle θ = 25°. Assume the ice is **frictionless**.

A) Draw the complete free body diagram for the sled. Label your coordinate axes and label each force. ***Failure to complete step A will result in zero partial credit for part B!***

B) The acceleration of the sled is **1.3 m/s²**. Find the tension in the rope **T** and the normal force **N**.



$$\sum F_x = T\cos\theta = ma$$

$$\sum F_y = T\sin\theta - mg + N = 0$$

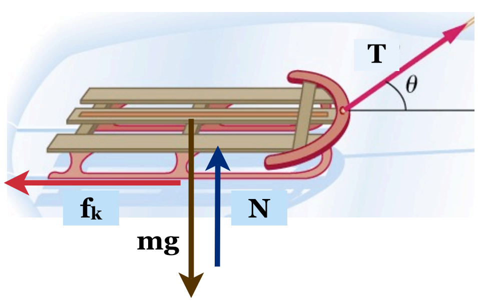
$$T\cos 25° = (8\text{kg})(1.3\,\tfrac{\text{m}}{\text{s}^2})$$

$$T = 11.5\text{N}$$

$$N = mg - T\sin\theta$$

$$N = (8\text{kg})(9.8\,\tfrac{\text{m}}{\text{s}^2}) - (11.5\text{N})\sin 25° = 73.5\text{N}$$

C) The boy moves onto a patch of sanded ice, which is *not frictionless*. If his acceleration is reduced to **0.50m/s²**, what is the **coefficient of friction μ_k** between the sled runners and the sand? Assume the boy pulls with a tension **T = 12N** at the same **25°** angle.



$$\sum F_x = T\cos\theta - f_k = ma$$

$$\sum F_y = T\sin\theta - mg + N = 0$$

$$T\cos\theta - \mu_k N = ma$$

$$N = mg - T\sin\theta$$

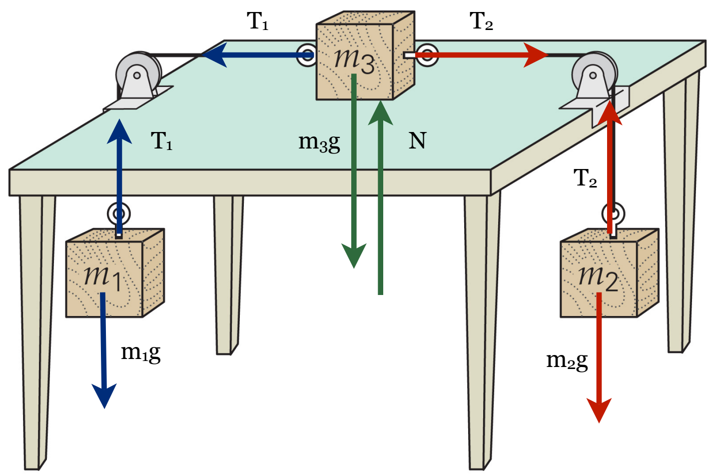
$$\mu_k N = T\cos\theta - ma$$

$$\mu_k = \frac{T\cos\theta - ma}{mg - T\sin\theta}$$

$$\mu_k = \frac{(12\text{N})\cos 25° - (8\text{kg})(0.5\,\tfrac{\text{m}}{\text{s}^2})}{(8\text{kg})(9.8\,\tfrac{\text{m}}{\text{s}^2}) - (12\text{N})\sin 25°} = 0.094$$

Problem 2: Homework Problem 4.110

The masses shown are attached by an inelastic cable. Mass $\mathbf{m_1 = 0.45kg}$, $\mathbf{m_2 = 0.60kg}$, and $\mathbf{m_3 = 0.90kg}$.

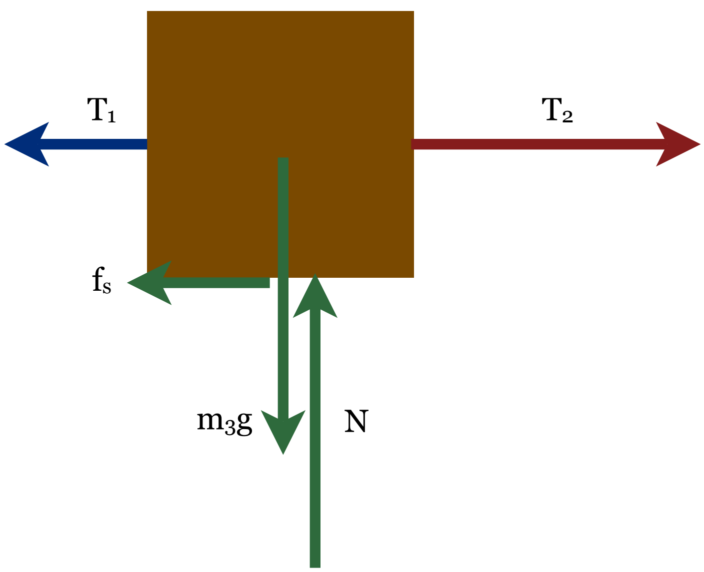


A) Assume that the table is a frictionless surface. Draw the complete free body diagram for **each mass**. Label your coordinate axes and label each force. ***Failure to complete step A will result in zero partial credit for part B!***

Forces are drawn and labeled on the figure.

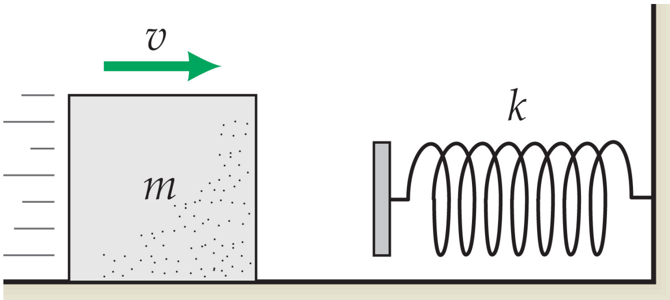
B) What is the minimum **coefficient of static friction μ_s** between m_3 and the table if the system is in equilibrium?

The force diagram for m_3 is re-drawn to include the force of static friction.



$$\sum F_1 = T_1 - m_1 g = 0$$
$$\sum F_2 = T_2 - m_2 g = 0$$
$$\sum F_{3x} = T_2 - T_1 - f_s = 0$$
$$\sum F_{3y} = N - m_3 g = 0$$
$$m_2 g - m_1 g - \mu_s (m_3 g) = 0$$
$$\mu_s = \frac{m_2 g - m_1 g}{m_3 g} = \frac{m_2 - m_1}{m_3}$$
$$\mu_s = \frac{(0.60 - 0.45)}{0.90} = 0.167$$

Problem 3: Homework Problem 5.84



The crate shown has a mass of **3 kg** and approaches the (massless) spring with a speed of **7.5m/s**. The spring constant **k = 1750N/m**.

A) How far will the mass compress the spring when its speed has been reduced to **5m/s**?

$$E_o = K_o = \tfrac{1}{2} m v_o^2$$

$$E_o = \tfrac{1}{2}(3\text{kg})\left(7.5\,\tfrac{\text{m}}{\text{s}}\right)^2 = 84.4\text{J}$$

$$E_A = K_A + U_A = \tfrac{1}{2} m v_A^2 + \tfrac{1}{2} k x_A^2$$

$$E_A = E_o$$

$$84.4\text{J} = \tfrac{1}{2}(3\text{kg})\left(5\,\tfrac{\text{m}}{\text{s}}\right)^2 + \tfrac{1}{2}\left(1750\,\tfrac{\text{N}}{\text{m}}\right) x_A^2$$

$$x_A = 0.231\text{m}$$

B) How much **total work** will be done by the spring on the crate to stop it?

$$W = K_f - K_o = 0 - 84.4\text{J} = -84.4\text{J}$$

C) When the crate comes to rest, how far will the spring be compressed from its original rest length?

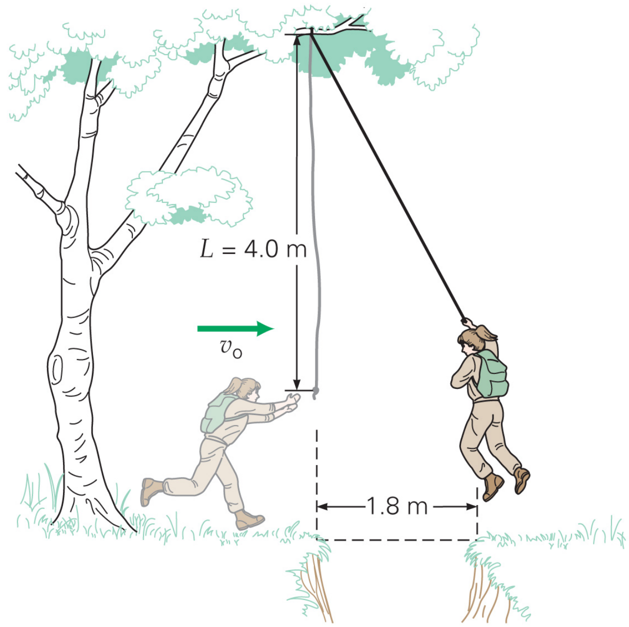
$$E_C = U_C = \tfrac{1}{2} k x_C^2$$

$$E_o = E_C$$

$$84.4\text{J} = \tfrac{1}{2}\left(1750\,\tfrac{\text{N}}{\text{m}}\right) x_C^2$$

$$x_C = 0.311\text{m}$$

Problem 4: Homework Problem 5.86



The girl shown gets a running start and launches herself with a initial horizontal velocity $\mathbf{v_o}$ = **3m/s**, at the same instant that she grabs the rope. This makes her the pendulum at the end of a **4.0m** rope as shown on the right.

A) Determine the **maximum angle** the rope makes with the vertical (HINT: It is *not* $\tan^{-1}(1.8/4.0)$, and you will receive *no* partial credit for calculating this angle!).

$$E_o = K_o = \tfrac{1}{2}mv_o^2$$

$$E_f = U_f = mgh = mgl(1-\cos\theta)$$

$$E_o = E_f$$

$$\tfrac{1}{2}mv_o^2 = mgl(1-\cos\theta)$$

$$1-\cos\theta = \frac{v_o^2}{2gl}$$

$$\cos\theta = 1-\frac{v_o^2}{2gl}$$

$$\theta = \cos^{-1}\left(1-\frac{v_o^2}{2gl}\right)$$

$$\theta = \cos^{-1}\left(1-\frac{3^2}{2(9.8)(4.0)}\right) = 27.7°$$

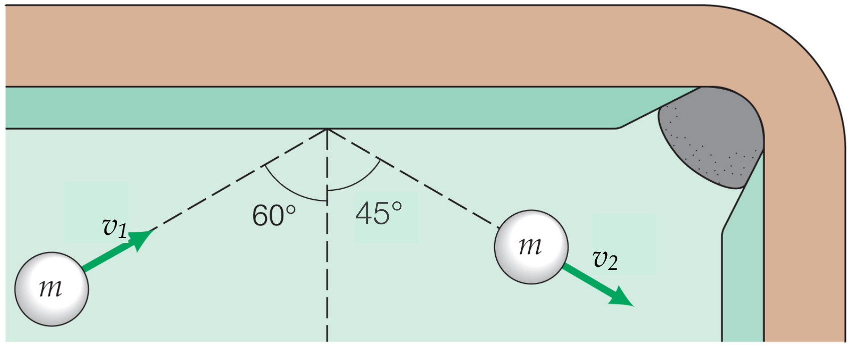
B) Based on your answer to part A, show whether she makes it across the ravine safely.

She makes it across if $x > 1.8$m:

$$\sin\theta = \frac{x}{l}$$

$$x = l\sin\theta = (4.0\text{m})\sin 27.7° = 1.86\text{m}$$

Problem 5: Homework Problem 6.18



The **0.250 kg** cue ball shown has a speed $\mathbf{v_1}$ = **12m/s** and strikes the bumper at an angle of **60°**. It rebounds with $\mathbf{v_2}$ = **10m/s** at angle of **45°** as shown.

The coordinate system should stay to the right = +x and up = +y. Any other coordinate system is going to almost guarantee that you do not calculate part C correctly.

A) What is the **momentum** $\mathbf{p_1}$ of the cue ball?

$$\vec{p}_1 = m\vec{v}_1$$
$$\vec{p}_1 = (0.250\text{kg})(12\,\tfrac{\text{m}}{\text{s}})[\sin 60°\,\hat{x} + \cos 60°\,\hat{y}]$$
$$\vec{p}_1 = [2.60\hat{x} + 1.50\hat{y}]\,\tfrac{\text{kg}\cdot\text{m}}{\text{s}}$$

B) Determine the **momentum** $\mathbf{p_2}$ of the cue ball just *after* it hits the bumper.

$$\vec{p}_2 = (0.250\text{kg})(10\,\tfrac{\text{m}}{\text{s}})[\sin 45°\,\hat{x} - \cos 45°\,\hat{y}]$$
$$\vec{p}_2 = [1.77\hat{x} - 1.77\hat{y}]\,\tfrac{\text{kg}\cdot\text{m}}{\text{s}}$$

C) Determine the *change* in momentum of the orange: $\Delta\mathbf{p} = \mathbf{p_2} - \mathbf{p_1}$.

$$\Delta\vec{p} = \vec{p}_2 - \vec{p}_1$$
$$\Delta p_x = 1.77 - 2.6 = -0.83\,\tfrac{\text{kg}\cdot\text{m}}{\text{s}}$$
$$\Delta p_y = -1.77 - 1.50 = -3.27\,\tfrac{\text{kg}\cdot\text{m}}{\text{s}}$$
$$\Delta\vec{p} = [-0.83\hat{x} - 3.27\hat{y}]\,\tfrac{\text{kg}\cdot\text{m}}{\text{s}}$$