Dr. Mohammad Hussein PHY 105 Recitation 1 12/10/2023

1. If the x component of a vector $\vec{A}$, in the xy plane, is half as large as the magnitude of the vector, the tangent of the angle between the vector and the x axis is:

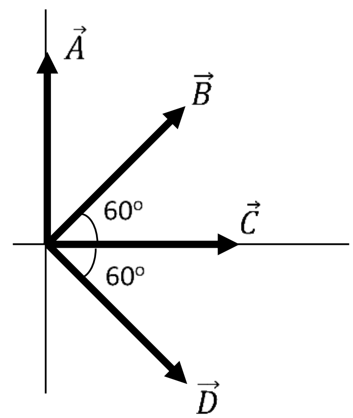
$\sqrt{3}$ 1/2 $\sqrt{3}/2$ 3/2 3

2. Find the magnitude and direction of -5**A** + **B**, where **A** = (23, 59), **B** = (90, -150).

446, 267° 446, 93° 25, 87° 25, 93° 180, 267°

3. In the figure, ALL FOUR vectors have the same magnitude of 5 units. The magnitude of the resultant vector $\vec{R} = \vec{A} + \vec{B} + \vec{C} + \vec{D}$ is

5 units 11.2 units 15 units 7.1 units 20 units



Dr. Mohammad Hussein PHY 105 Recitation 2 19/10/2023

1. Blood flows through an artery at 1.0 m/s for 0.50 s, then at 0.60 m/s for another 0.50 s through a different artery. Calculate the average speed during the entire time interval.
0.8 m/s

Free tip: Determine the average speed by first calculating the total distance traveled and then dividing it by the total time elapsed.
Insight: Average speed is a weighted average according to how much time the blood spends traveling at each speed. Because the time intervals are the same, the blood spends equal times at 1.0 m/s and 0.60 m/s, and its average speed is simply the arithmetic mean, and thus equal 0.80 m/s.

2. You run at 9.1 km/h for 5.0 km, then you jump into a car and drive an additional 13 km. With what average speed must you drive your car if your average speed for the entire 18 km is to be 25 km/h?
76.2 km/h

Insight: Notice that the average speed is not the average (arithmetic mean) of 9.1 km/h and 76.2 km/h (which would be 42.7 km/h) because you spend a much longer time running at low speed than you spend driving at high speed.

3. A car is traveling due north at 23.6 m/s. Find the velocity of the car after 7.10 s if its average acceleration is (a) 1.30 m/s^2 due north, or (b) 1.15 m/s^2 due south.
(a) 32.8 m/s north
(b) 15.4 m/s north

Insight: In physics we almost never talk about *deceleration*; it is a misleading term. In this problem south is considered the negative direction, and in part (b) the car is slowing down.

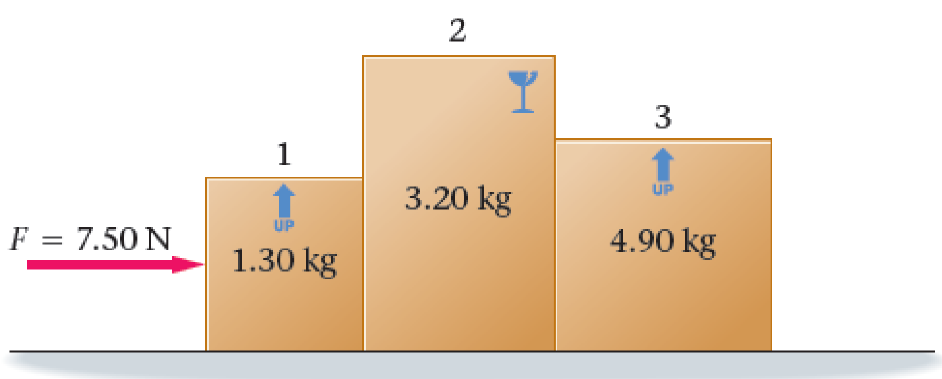
4. Moving with an initial velocity of +9.2 m/s, a car has an average acceleration of -1.81 m/s^2. How much time does it take for the car to decrease its velocity to +5.5 m/s?
2.0 s

Dr. Mohammad Hussein PHY 105 Recitation 3 26/10/2023

1. A force of magnitude F acts on an object of mass m that is initially at rest and accelerates it to speed v in a time T. Suppose the mass of the object is doubled, and the magnitude of the force acting on it is quadrupled (i.e., becomes 4F). In terms of T, how much time does it take for the object to accelerate from rest to a speed v now?
0.5 T

Insight: If the mass m were quadrupled instead of doubled, the acceleration would be a_{new} = 4F/4m =a_{old}, and hence the time required to accelerate to speed v would remain unchanged.

2. A force *F* pushes on the first of three boxes in the manner indicated by the figure blow. Find the magnitude of the contact force:
(a) between boxes 1 and 2. 6.46 N
(b) between boxes 2 and 3. 3.91 N



Free tip: The boxes must each have the same acceleration, but because they have different masses the net force on each must be different. Note also that the force exerted by box 1 to the right accelerates boxes 2 and 3.
Note: You should be able to validate your answers by solving each part using two different approaches.

3. An object acted on by three forces moves with constant velocity. One force acting on the object is in the positive x direction and has a magnitude of 6.5 N; a second force has a magnitude of 4.4 N and points in the negative y direction. Find the magnitude and direction of the third force acting on the object.
7.8 N, $\theta = 146^{o}$ based on our convention.

Insight: The vector sum of all the forces acting on any object that is not accelerating must be zero. It's extremely important to distinguish between the absence of forces acting on an object and the absence of a net force acting on the object.

4. A newborn baby's brain grows rapidly. In fact, it has been found to increase in mass by about 1.6 mg per minute.
(a) How much does the brain's weight increase in one day? 0.023 N
(b) How much time does it take for the brain's weight to increase by 0.15 N? 6.6 days
Hint: mg stands for milligram.

Insight: The weight of the brain of the newborn is approximately 300 grams (10% of body weight) in contrast to the adult brain, which weighs approximately 1400 grams (2% of body weight). If the newborn brain kept gaining weight at the rate of 1.6 mg/min it would reach adult size in 477.4 days or about 16 months. In reality it reaches the adult brain weight between six and fourteen years of life.
Hmm, I bet you will enjoy your next semester anatomy and physiology classes!

5. When you lift a ball straight upward by an applied force of 82 N, the ball accelerates upward with an acceleration a. If you lift with a force of 92 N, the ball's acceleration is 2a.
Find:
(a) the weight of the ball. 72 N
(b) the acceleration a. 1.36 m/s^2

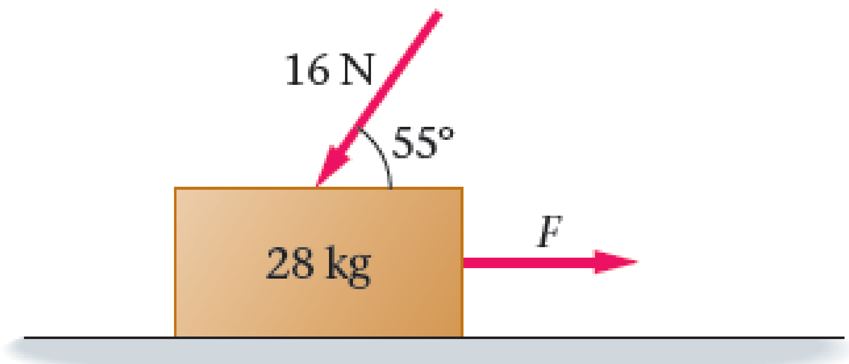
Insight: In the first case, 72 N of force supported the weight of the ball and 10 N accelerated it at a rate of 1.36 m/s^2. In the second case, 20 N of net force accelerated the ball at a rate of 2.72 m/s^2.

Dr. Mohammad Hussein PHY 105 Recitation 4 16/11/2023

1. The block shown (1.8 kg) slides on a horizontal surface with a speed of v = 0.80 m/s and an acceleration of magnitude a = 2.8 m/s^2.
What is the coefficient of kinetic friction between the block and the surface? 0.29

Insight: The acceleration of the block is caused by kinetic friction, which is the only force acting on the block in the horizontal direction.

2. What is the minimum horizontal force *F* needed to make the box start moving in the figure below? The coefficients of kinetic and static friction between the box and the floor are 0.24 and 0.41, respectively. 127.1 N

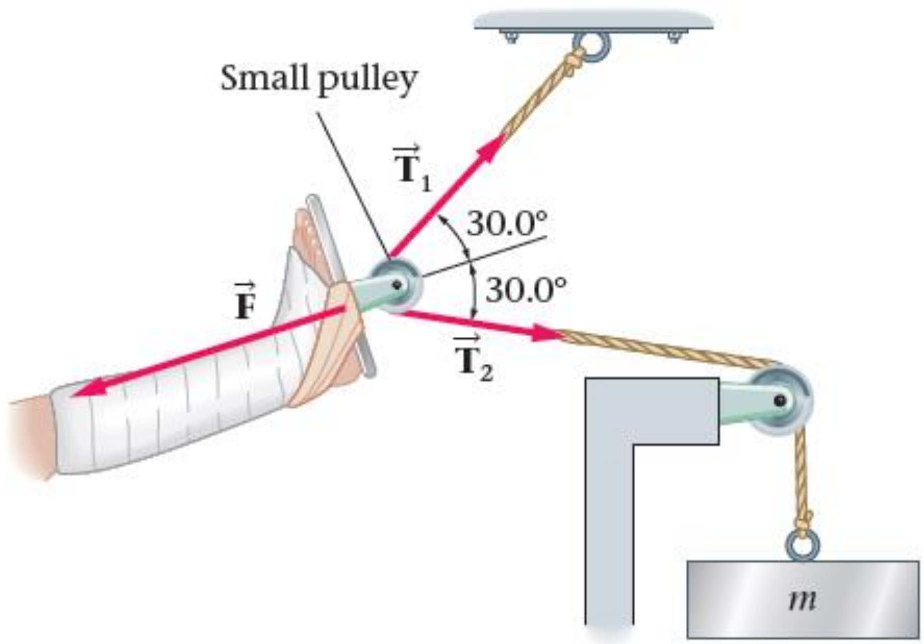


Insight: When the box begins moving the coefficient of kinetic friction (not static friction) determines the friction force, but the normal force remains the same. Thus to slide the box at constant speed the applied force needs to be reduced to a magnitude given by *F* = 78.2 N.

3. A block of mass m rests on a larger block of mass M that rests on a table. The coefficients of static and kinetic friction between **all surfaces** are μ_s and μ_k, respectively. What is the minimum horizontal force, F, applied to the lower block (M) that will cause it to slide out from under the upper block? $\mu_s(2m + M)g$

We now ask, Why is it wrong to simply say that F equal $\mu_s(m + M)g$? The applied force must overcome the static friction from **both** the top block and the bottom surface. The wrong answer specifies the static friction from only the bottom surface.
This problem is related to problem 14 of the 1st assignment: please check PHY_105_Assignment_1.pdf.

4. A broken leg in a cast is supported using a traction device, as shown in the figure. Find the magnitude of the force **F** exerted by the leg on the small pulley. (By Newton's third law, the small pulley exerts an equal and opposite force on the leg.) Let the mass m be 2.27 kg. 38.5 N



Insight: The rope tension is equal to the weight of the hanging mass and will everywhere be the same because the pulleys are assumed frictionless. The traction device is arranged to produce a force that is parallel to the leg bone so that it can heal straight. However, the force of gravity on the leg has been ignored here, and in reality there must be an upward component of the force exerted on the leg. **Please consult Lecture_5_2.pdf**.

Dr. Mohammad Hussein PHY 105 Recitation 5 6/12/2023

1. The time T required for one complete oscillation of a mass m on a spring of force constant k is $T = 2\pi\sqrt{\frac{m}{k}}$. Find the dimensions k must have for this equation to be dimensionally correct. Use [M] to represent the dimension of mass, [T] for time, and [L] for length. $\frac{[M]}{[T]^2}$

Insight: This is a dimensional analysis question. The $4\pi^2$ does not contribute any dimensions.

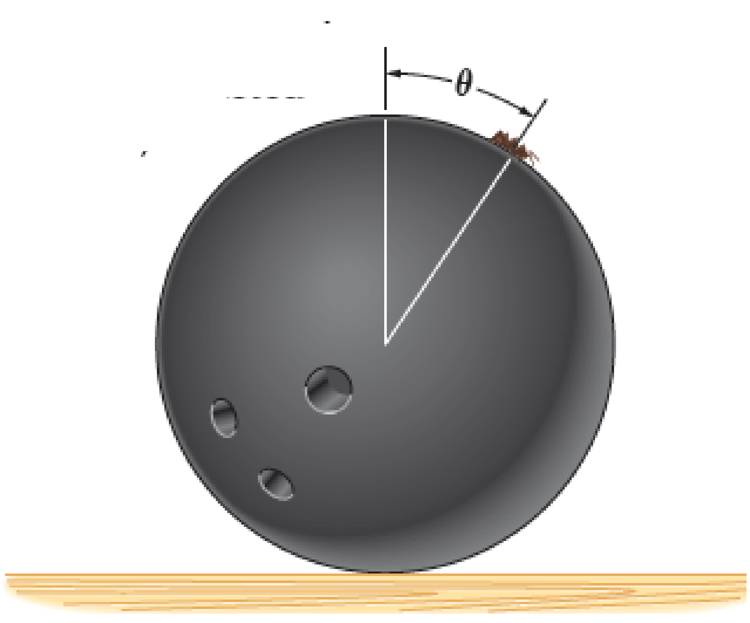
2. Acceleration is related to velocity and time by the following expression: $a = v^p t^q$.
Find the powers p and q that make this equation dimensionally consistent. p = 1 and q = -1

Insight: Sometimes you can determine whether you've made a mistake in your calculations simply by checking to ensure the dimensions work out correctly on both sides of your equations.

3. Vector **A** points in the negative x direction. Vector **B** points at an angle of 30.0° above the positive x axis. Vector **C** has a magnitude of 15 m and points in a direction 40.0° below the positive x axis. Given that **A** + **B** + **C** = 0, find the magnitudes of **A** and **B**.
A = 28.2 m and B = 19.3 m.

4. An ant walks away from the top of a smooth bowling ball, as depicted at right. If the ant starts to slip when the normal force on its feet equals one-half its weight, at what angle θ does slipping begin?
60°

Insight: The normal force itself will not be zero until θ = 90°, at which point nothing will stop the ant's fall unless it has sticky feet!



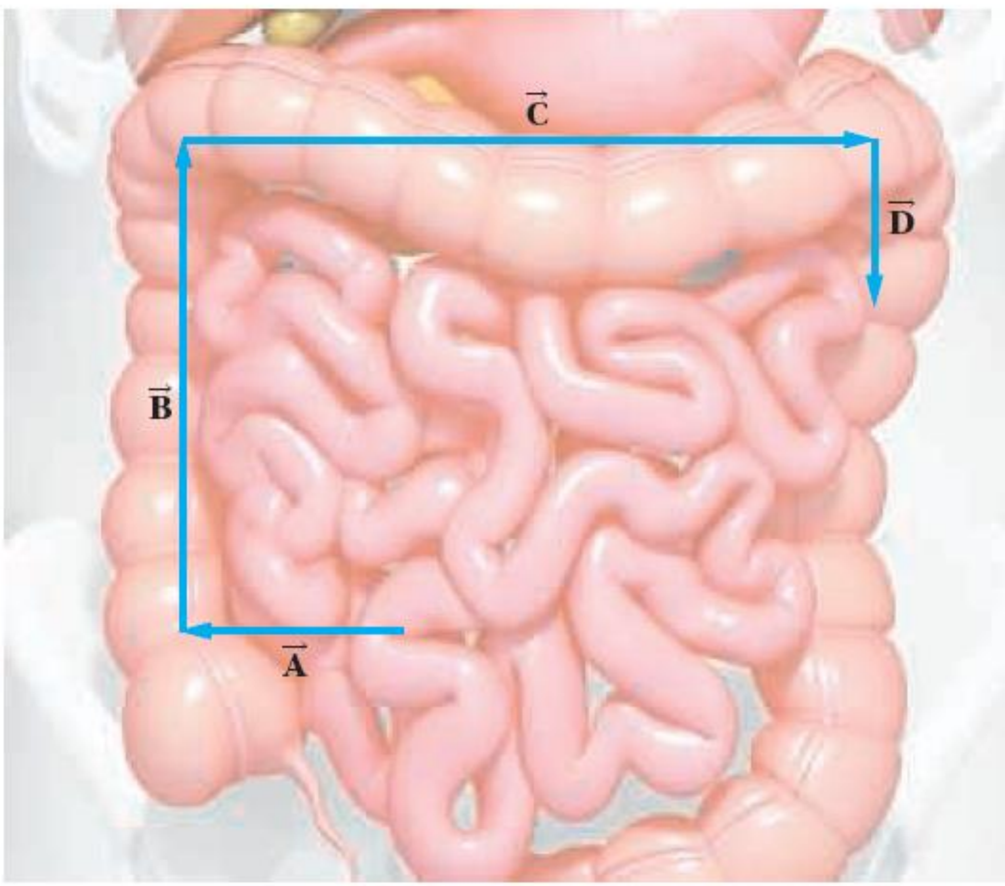
5. When two people push together in the same direction on an object of mass m they cause an acceleration of magnitude a_1. When the same people push in opposite directions with the same amount of force each, the acceleration of the object has a magnitude a_2. Determine the magnitude of the force exerted by each of the two people in terms of m, a_1, and a_2.
One force equal $\frac{1}{2}m(a_1 + a_2)$, the another one equal $\frac{1}{2}m(a_1 - a_2)$

6. A food particle from your breakfast takes a circuitous path through your digestive system. Suppose its motion over a period of time can be represented by the four displacement vectors depicted in the figure below. Let the vectors have magnitudes $A = 8.0$ cm, $B = 16$ cm, $C = 23$ cm, and $D = 5.6$ cm. If the average speed of the particle is 0.010 mm/s, what is its average velocity (in mm/s) over the time interval of the four displacements? Give its direction relative to the direction of vector **A**.

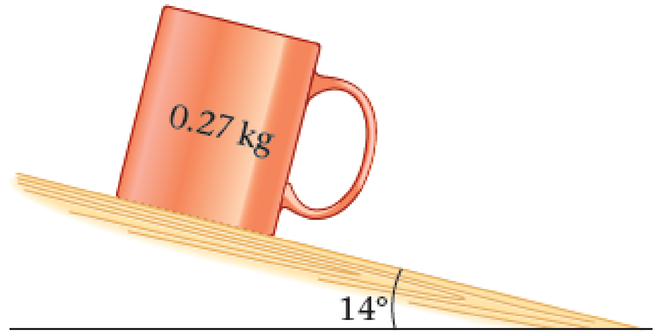
0.0034 mm/s at 214.35° counterclockwise from **A**.

Free tip: First, find the total displacement of the food particle. Give its direction counterclockwise from **A**. To find the average velocity of the food particle, use the average speed value to find the total time elapsed, and then use the displacement and the time to calculate the average velocity.

Insight: Food particles (called chyme) travel faster in the human small intestine, requiring at least 1.7 hours to traverse the 6.1-m length at an average speed of about 1.0 mm/s.

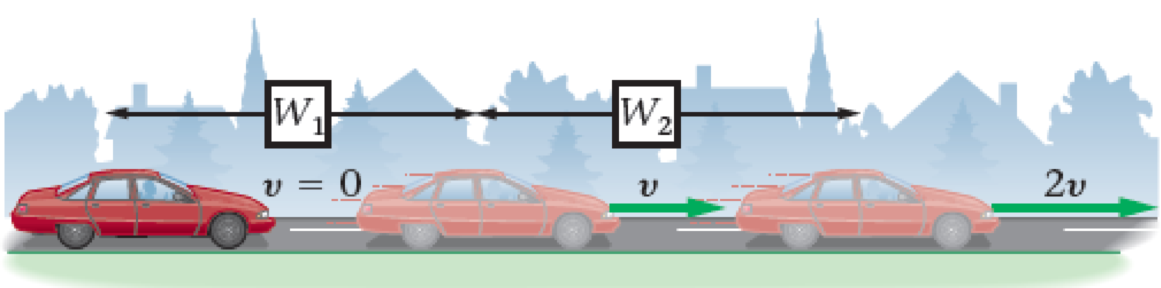


7. A mug rests on an inclined surface, as shown. What is the minimum coefficient of static friction required to keep the mug from sliding? 0.25

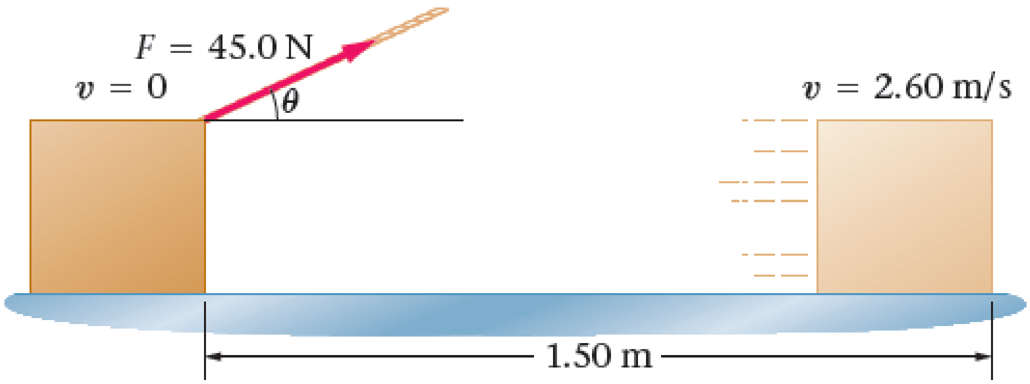


8. The human brain consumes about 22 W of power under normal conditions, though more power may be required **during exams, hmm!**
(a) For what amount of time can one Snickers bar (see the note below) power the normally functioning brain? (b) At what rate must you lift a 3.6-kg container of milk (one gallon) if the power output of your arm is to be 22 W? (c) How much time does it take to lift the milk container through a distance of 1.0 m at this rate? Note: each Snickers bar contains 280 Cal of energy, and each Cal is equivalent to 4186 J.
(a) 14.8 hours. (b) 0.62 m/s. (c) 1.6 s.
Insight: The human brain converts chemical energy into electrical energy and finally into heat energy. The power required for doing mechanical work is typically larger than that consumed by the brain. In practice it probably takes you a little less than a second to lift the milk 1.0 m, so you expend about 40 W or twice the power lifting the milk than your brain consumes.

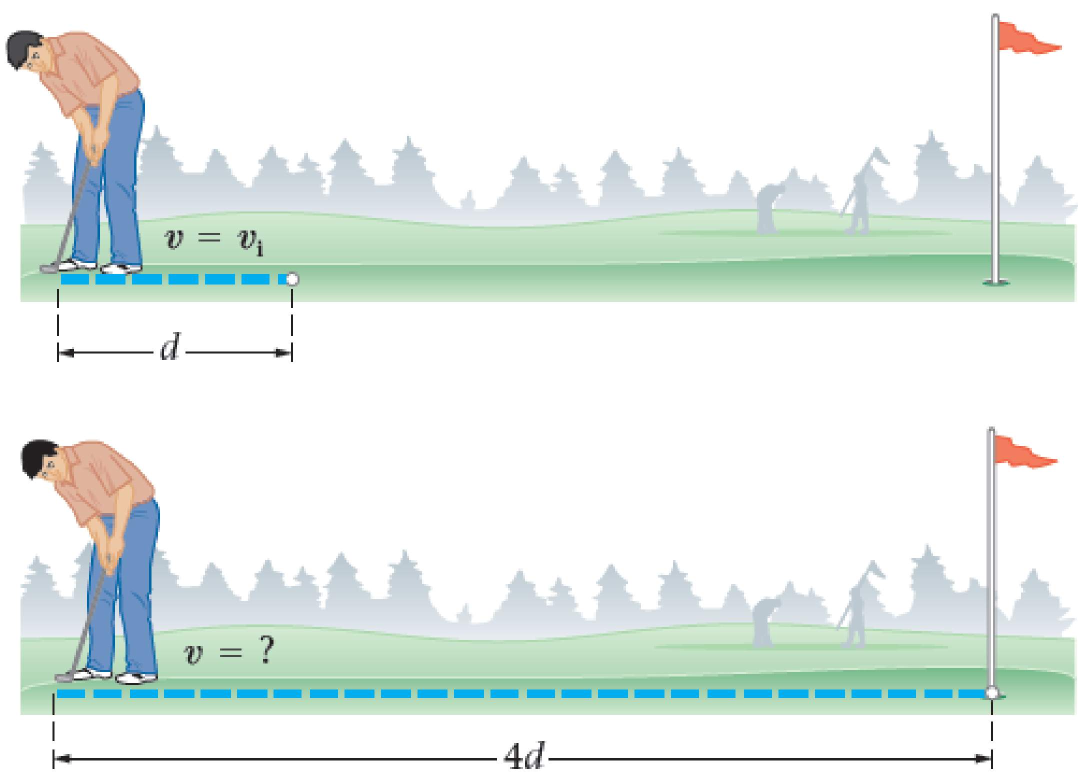
9. (a) To accelerate a certain car from rest to the speed *v* requires the work W_1, as shown in the sketch. The work needed to accelerate the car from *v* to 2*v* is W_2. Which of the following statements is correct: $W_2 = W_1$, $W_2 = 2W_1$, $W_2 = 3W_1$, $W_2 = 4W_1$?
(b) Which of the following is the best explanation for your prediction?
I. The increase in speed is the same, so the work is also the same.
II. To double the speed requires double the work.
III. Kinetic energy depends on v^2, and hence it takes four times as much work to increase the speed to 2*v*.
IV. Four times as much work is required to go from 0 to 2*v* as to go from 0 to *v*. Therefore, the work required to increase the speed from *v* to 2*v* is three times the original work.
(a) The required work is $W_2 = 3W_1$. (b) The best explanation is IV.
Insight: A common misconception is to reason that because we increase the speed by the same amount in each case, the work required is the same. It is not, and the reason is that work depends on the speed squared rather than on the speed itself.



10. A block rests on a horizontal frictionless surface. A string is attached to the block, and is pulled with a force of 45.0 N at an angle θ above the horizontal, as shown in the figure below. After the block is pulled through a distance of 1.50 m, its speed is 2.60 m/s, and 50.0 J of work has been done on it. (a) What is the angle θ? 42.2°. (b) What is the mass of the block? 14.8 kg.

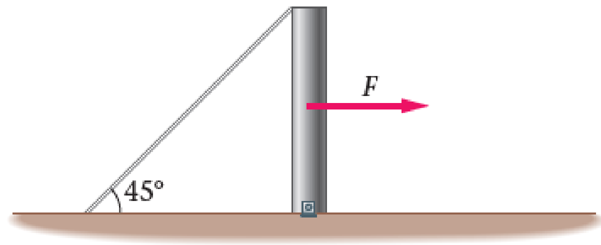


11. A golfer badly misjudges a putt, sending the ball only one-quarter of the distance to the hole. The original putt gave the ball an initial speed of v_i. If the force of resistance due to the grass is constant, would an initial speed of (a) $2v_i$, (b) $3v_i$, or (c) $4v_i$ be needed to get the ball to the hole from its original position? $2v_i$



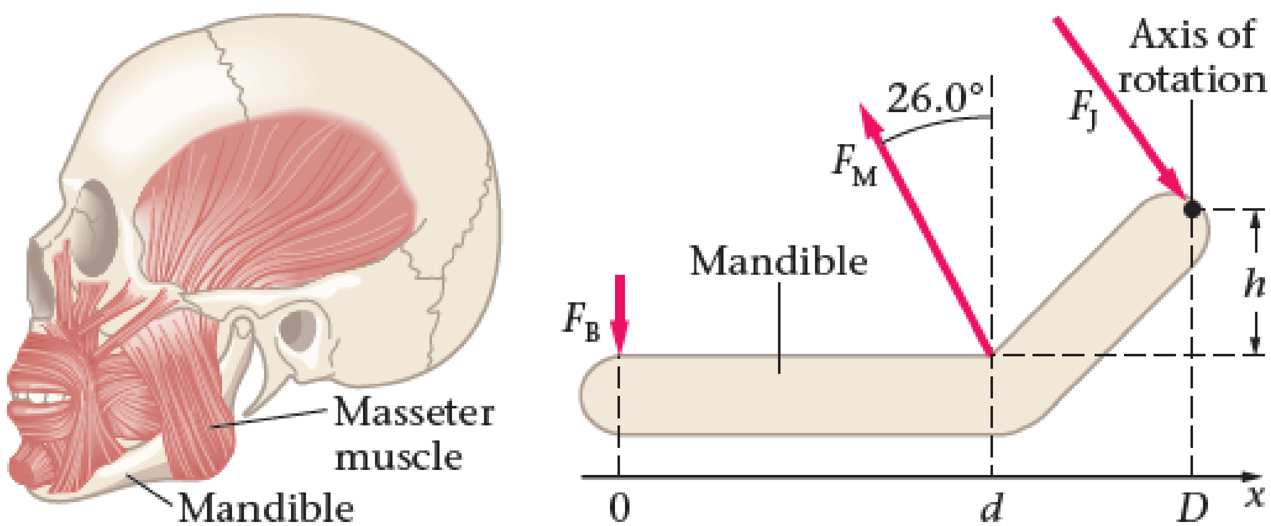
Dr. Mohammad Hussein PHY 105 Recitation 6 6/15/2023

1. A rigid, vertical rod of length L with negligible mass is connected to the floor by a bolt through its lower end, as shown next. The rod also has a wire connected between its top end and the floor. If a horizontal force *F* is applied at the midpoint of the rod, find (a) the tension in the wire, and (b) the horizontal and (c) the vertical components of force exerted by the bolt on the rod. (a) $T = \frac{F}{\sqrt{2}}$ (b) $\boldsymbol{F_x} = -\frac{1}{2}F$ (c) $\boldsymbol{F_y} = +\frac{1}{2}F$



Insight: The bolt force has a magnitude of $\frac{F}{\sqrt{2}}$ and points 45° above the horizontal and to the left.

2. The masseter muscle, the principal muscle for chewing, is one of the strongest muscles for its size in the human body. It originates on the lower edge of the zygomatic arch (cheekbone) and inserts in the angle of the mandible. Assume that the mandible is in static equilibrium. Referring to the diagram below, where d = 7.60 cm, D = 10.85 cm, and h = 3.15 cm, (a) find the torque produced about the axis of rotation by the masseter muscle. The force exerted by the masseter muscle is F_M = 455 N. (b) Find the biting force, F_B, exerted on the mandible by the upper teeth. Find (c) the horizontal and (d) the vertical component of the force F_J exerted on the mandible at the joint where it attaches to the skull. (a) 19.6 N.m (b) -181 N (c) +199 N (d) -228 N



Insight: While the biting force is large (181 N), the 303-N total force on the joint is an indicator of how strong the joints and muscles must be in order for the jaw to work correctly!

3. Suppose you are holding a barbell in your hand, as shown in **Figure 1**. Your biceps supports your forearm. The biceps is attached to the bone of the forearm at a distance r_b = 2.0 cm from the elbow, as shown in **Figure 2**. The mass of your forearm is 0.85 kg. The length of your forearm is 31 cm. Your forearm makes an angle θ = 75° with the vertical, as shown in Figure 2. The barbell has a mass of 15 kg. What is the force that the biceps must exert to hold up your forearm and the barbell? Assume that the biceps exerts a force perpendicular to the forearm at the point of attachment. T_b = (approximately) 2260 N

Figure 1

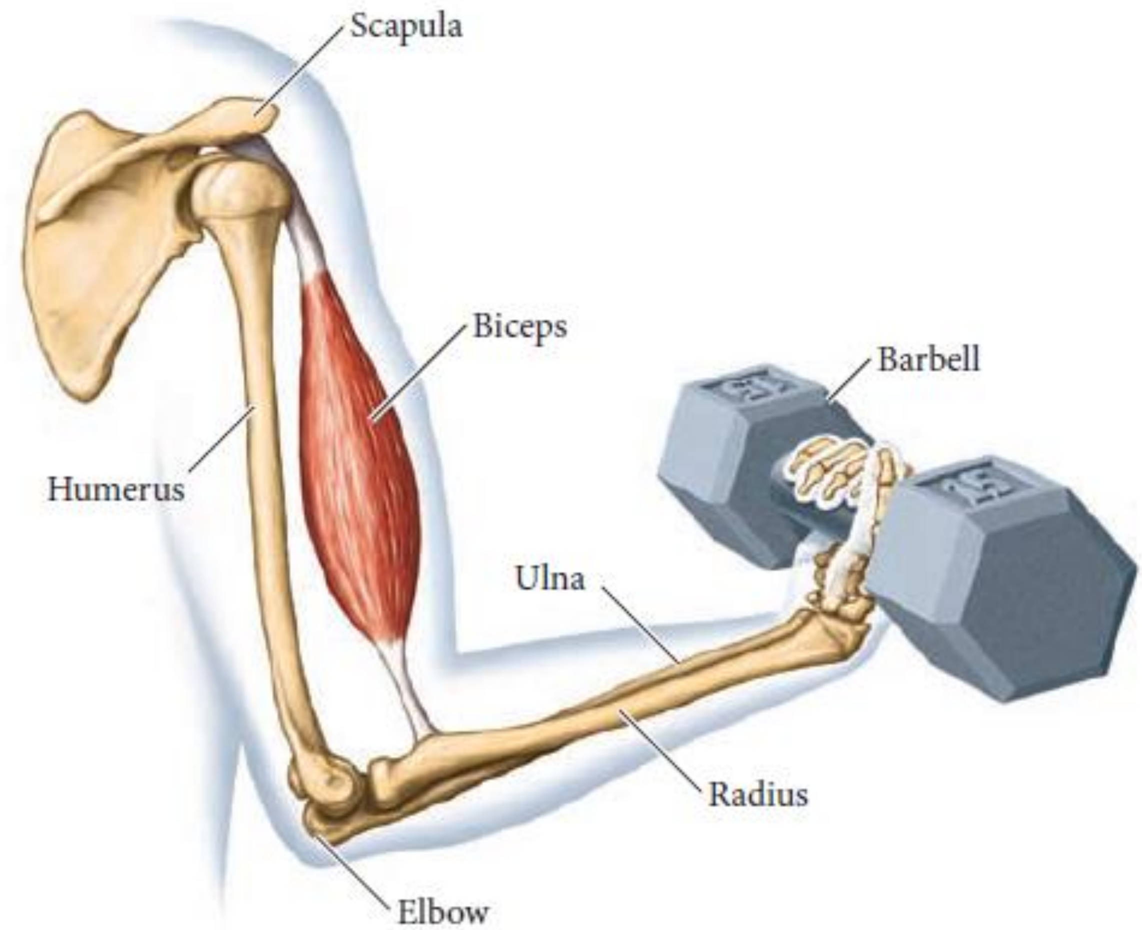
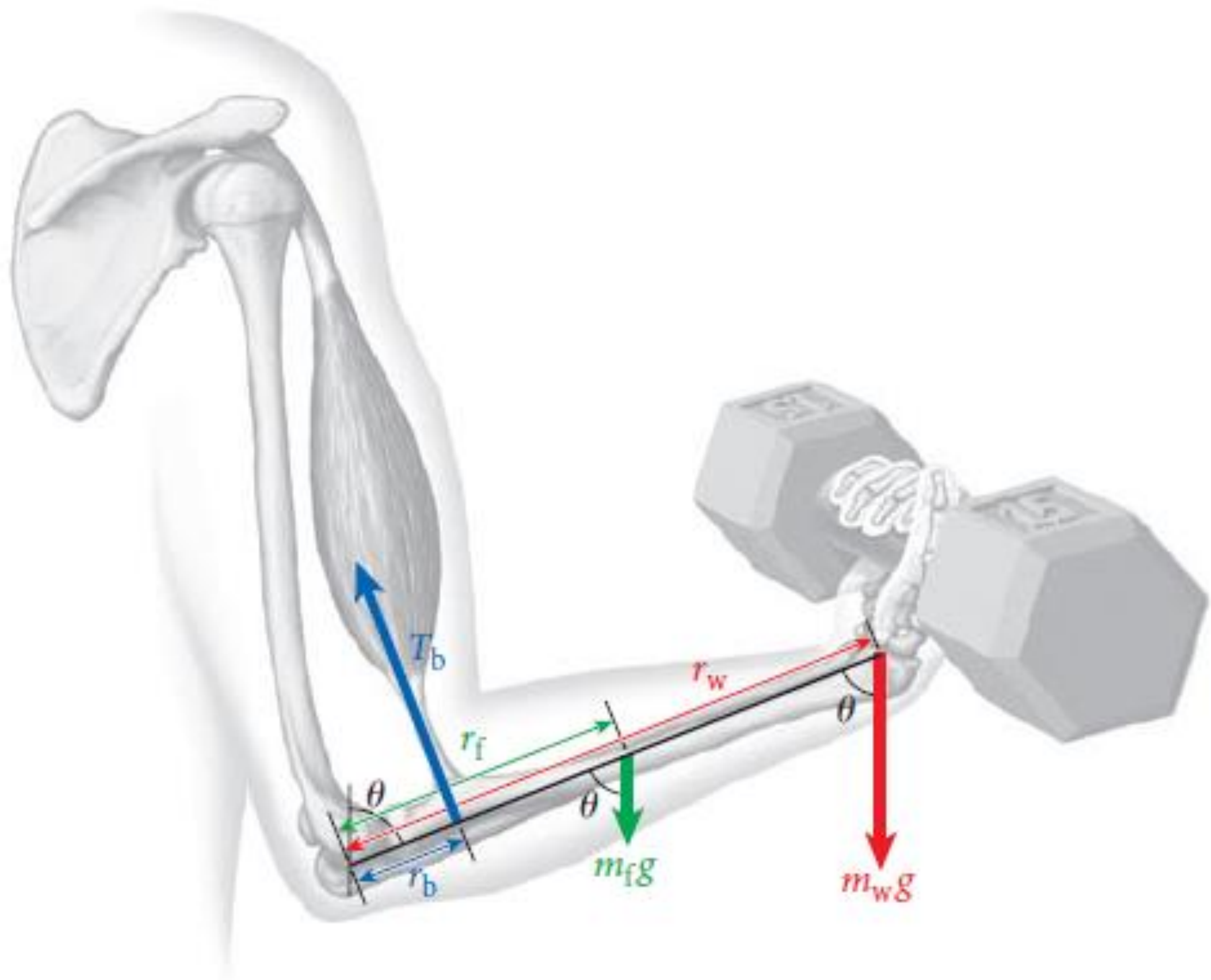


Figure 2

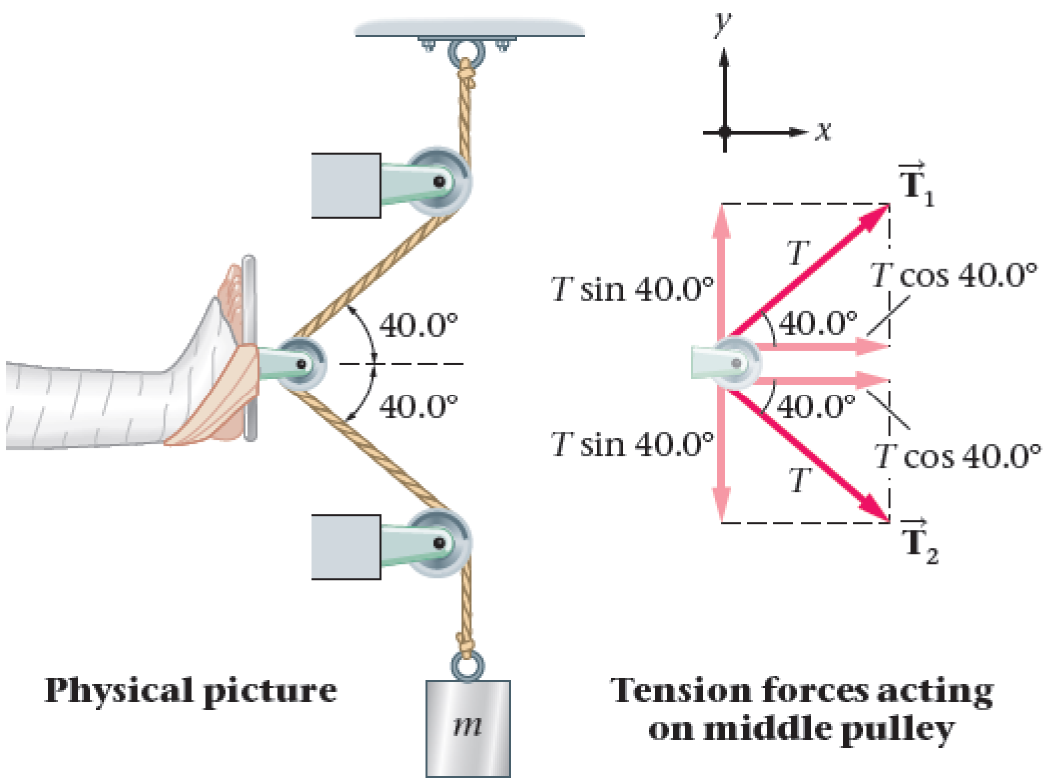


Dr. Mohammad Hussein **PHY 105 - Fall 2022** **Date: 14/12/2022**

SETTING A BROKEN LEG WITH TRACTION

EXAMPLE

A traction device employing three pulleys is applied to a broken leg, as shown in the sketch. The middle pulley is attached to the sole of the foot, and a mass *m* supplies the tension in the ropes. Find the value of the mass *m* if the force exerted on the sole of the foot by the middle pulley is to be 165 N.



We begin by noting that the rope supports the hanging mass *m*. As a result, the tension in the rope, *T*, must be equal in magnitude to the weight of the mass: $T = mg$.

Next, **the pulleys simply change the direction of the tension without changing its magnitude.**

Therefore, **the net force exerted on the sole of the foot by the middle pulley** is the sum of the tension *T* at 40.0° above the horizontal plus the tension *T* at 40.0° below the horizontal. We will calculate the net force component by component.

1. First, consider the tension that acts upward and to the right on the middle pulley. Resolve this tension into *x* and *y* components:

$T_{1,x} = T \cos 40.0°$ $T_{1,y} = T \sin 40.0°$

2. Next, consider the tension that acts downward and to the right on the middle pulley. Resolve this tension into *x* and *y* components. Notice the minus sign in the *y* component:

$T_{2,x} = T \cos 40.0°$ $T_{2,y} = -T \sin 40.0°$

3. Sum the *x* and *y* components of the force acting on the middle pulley. **We see that the net force acts only in the *x* direction, as one might expect from <u>symmetry</u>**:

$\sum F_x = T \cos 40.0° + T \cos 40.0° = 2T \cos 40.0°$

$\sum F_y = T \sin 40.0° - T \sin 40.0° = 0$

4. Step 3 shows that the net force acting on the middle pulley is $2T \cos 40.0°$.

Set this force equal to 165 N and solve for *T*:

$2T \cos 40.0° = 165$ N

$T = 165$ N / [2 cos 40.0°] = 108 N

5. Solve for the mass, *m*, using $T = mg$:
$m = T/g = 108 \text{ N}/9.81 \text{ m/s}^2 = 11.0$ kg

INSIGHT

This pulley arrangement "**<u>magnifies the force</u>**" in the sense that a 108-N weight attached to the rope produces a 165-N force **exerted on the foot by the middle pulley**. Notice that the tension in the rope always has the same value—T = 108 N—as expected with ideal pulleys, but because of the arrangement of the pulleys the force applied to the foot by the rope is $2T \cos 40.0° > T$.

<u>The force exerted on the foot by the middle pulley produces an opposing force in the leg that acts in the direction of the head (a cephalad force), as desired to set a broken leg and keep it straight as it heals.</u>

PRACTICE PROBLEM

(a) Would the required mass *m* increase or decrease if the angles in this device were changed from 40.0° to 30.0°?
(b) Find the mass *m* for an angle of 30.0°.
[Answer: (a) *m* would decrease. (b) 9.71 kg]