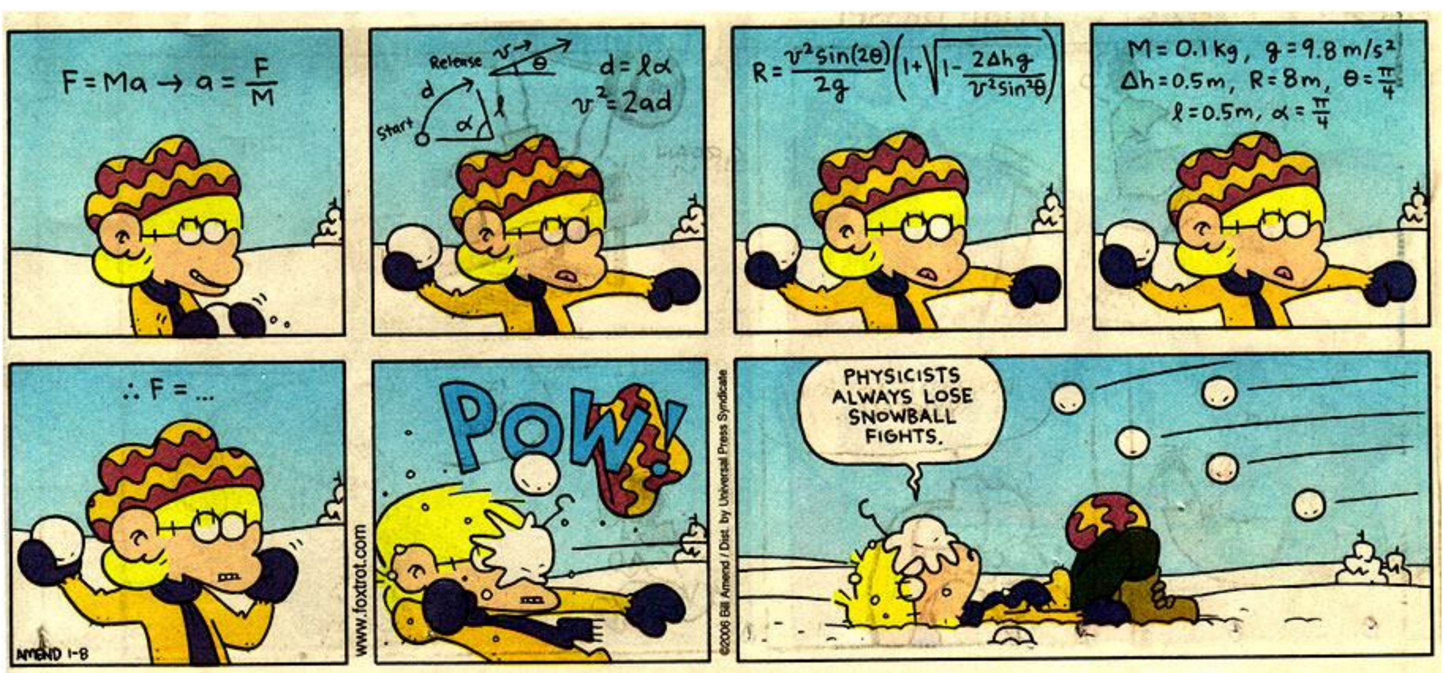
James M. Hill

Physics 122 Problem Set

2014 – 2015



Mr. P. MacDonald

1. A car accelerates from 15 m/s [E] to 25 m/s [W] in 26 seconds.
    a. Calculate the acceleration of the car. { $\vec{a}$ = –1.54 m/s^2}
    b. Calculate the displacement of the car during the above acceleration. {$\vec{d}_f$ = –130 m}
    c. Calculate the velocity of the car if it continues to accelerate for an additional 15 seconds. {$\vec{v}_f$ = –48.0 m/s^2}

2. A ball is kicked 20 m [E], 35 m [W], 50 m [E], and finally 10 m [W]. If all of this takes place in 52 seconds calculate:
    a. the average speed of the ball. {v_{sp} = 2.2 m/s}
    b. the average velocity of the ball. {$\vec{v}_{avg}$ = 0.48 m/s}

3. A person is standing atop a cliff that is 250 m high cliff overlooking the water below. Not happy with the new iPhone 5S she drops the phone. Hints: use the acceleration of gravity for the Earth; and when an object is dropped the initial velocity is zero.
    a. Calculate the time it takes for the iPhone to hit the water below. {t = 7.1 s}
    b. Calculate the velocity as it enters the water. {$\vec{v}_f$ = –70.0 m/s}
    c. Calculate the velocity of the iPhone 75 m above the water. {$\vec{v}_f$ = –58.6 m/s}

4. Standing on the ground a person throws a spear. It leaves his hand with an upward velocity of 21 m/s.
    a. Calculate the length of time the spear will be traveling upwards. {t = 2.1 s}
    b. Calculate the spear's maximum height. {$\vec{d}_f$ = 22.5 m}
    c. Calculate the velocity of the spear when it is 15 m above the ground. {$\vec{v}_f = \pm$12.1 m/s}

5. A plane changes its velocity from 215 m/s [S] to 300 m/s [N]. The acceleration was 5.72 m/s^2.
    a. Calculate the time it took for the plane to change its velocity. {t = 90.0 s}
    b. Calculate the displacement of the plane in that time. {$\vec{d}_f$ = 3830 m}
    c. Calculate the distance the plane traveled in that time. Hint: find the distance the plane traveled in both the South and Northern directions. {d = 11 900 m}

6. A fighter jet initially flying 250 m/s [E] turns to fly a supersonic 400 m/s [W]. This happens in 12 seconds.
    a. Calculate the acceleration of the plane. {$\vec{a}$ = –54.2 m/s^2}
    b. Calculate the displacement of the plane in that time. {$\vec{d}_f$ = 900 m}
    c. Calculate the distance traveled by the plane in that time. {d = 2050 m}

7. A cannonball is fired from a 250 m high cliff towards a galleon. Its vertical, upward, velocity is 75 m/s.
    a. Calculate the maximum height above the water the cannonball reaches. {$\vec{d}_f$ = 536 m}
    b. Calculate the vertical velocity with which the cannonball strikes the galleon. {$\vec{v}_f$ = –103 m/s}
    c. Calculate the length of time the cannonball takes to travel from the cannon to the galleon. {t = 18.1 s}

8. A car is driving around a circular track. The track has a radius of 100 m. Starting from rest it accelerates to 30 m/s in 12 seconds then holds a constant speed of 30 m/s.
    a. Calculate the distance moved along the track during the acceleration. {d = 180 m}
    b. Calculate the average speed and velocity when the car is half way around the track. {v_{sp} = 19.0 m/s; $\vec{v}_{avg}$ = 12.1 m/s}
    c. Calculate the average speed and velocity when the car has returned to its starting position. {v_{sp} = 23.3 m/s; $\vec{v}_{avg}$ = 0.0 m/s }
    d. **Challenge**: Calculate the average velocity during the car's first 12 and 20 seconds of motion. {$\vec{v}_{avg}$ = 6.5 m/s; $\vec{v}_{avg}$ = 4.3 m/s }

Introduction to Forces

1. Define inertia.

2. Describe inertial and gravitational mass.

3. Suppose a baseball and a table-tennis ball were traveling with the same velocity and you caught one in each hand – which would hurt more and why?

4. Forces break down in to which two groups? Give three examples of each.

5. Define and compare an object's weight and mass.

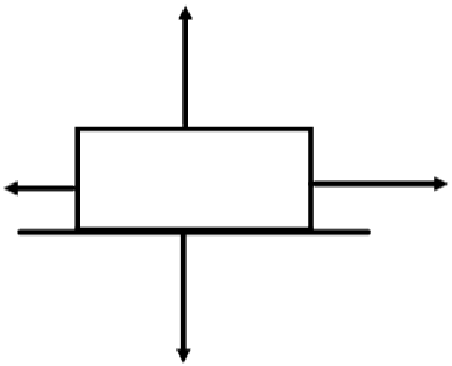
6. In the formula for the force of gravity, how is the distance between masses accounted for?

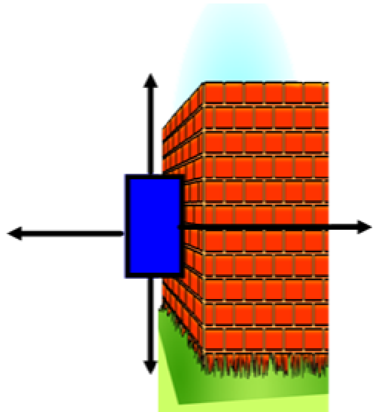
7. Is the force of gravity acting on objects in Earth's orbit?

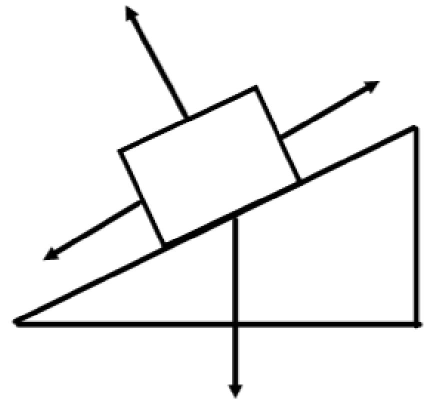
8. Suppose you are on the ISS (which would be awesome), would you need to push a 50 kg object with a different force than a 100 kg object? Explain.

Force of Friction Review Questions

1. In the diagrams below, label the force of friction and normal force by the appropriate arrows.







2. Summarize what physical process causes friction.

3. How does friction depend on surface area between the two objects rubbing together? Think of a case where surface area could play a significant role in the force of friction.

4. Summarize the three situations when basic surface friction theory will not be applied.

5. Why will two identical pieces of smooth metals not fuse together?

6. What are the two types of friction? For two given surfaces which force of friction is greater?

7. Suppose you apply a force to a heavy object. Describe how the two forces of friction affect the object's motion.

8. A textbook is sitting on a desk. Is there a force of friction present? Provide an explanation.

9. In what direction does friction always act?

10. Describe how heat is created when two surfaces are rubbed together.

Physics 112: Force Practice

1. A 25 kg crate is pulled at a constant velocity with an applied force of 125 N.
    a. Calculate the force of friction. (-125 N)
    b. Calculate the normal force on the crate. (245 N)
    c. Calculate the coefficient of kinetic friction. (0.51).

2. A sled has a weight of 75 N and is being pulled with a net force of 15 N. The coefficient of kinetic friction is 0.19.
    a. What is the mass of the sled? (7.6 kg)
    b. What is the force of friction? (14.25 N)
    c. What is the applied force? (29.25 N)

3. A 55 kg box is moved with a net force of 28 N. The applied force necessary is 185 N.
    a. What is the force of friction? (-157 N)
    b. What is the normal force? (540 N)
    c. What is the coefficient of kinetic friction? (0.29)

4. A box is being pulled across the floor at a constant velocity with an applied force of 184 N. The coefficient of kinetic friction is 0.26.
    a. What is the force of friction? (-184 N)
    b. What is the force of gravity on the box? (708 N)
    c. What is the mass of the box? (72.2 kg)

5. A 46 kg object is being pulled with an applied force of 200 N. The coefficient of kinetic friction is 0.18.
    a. What is the force of gravity on the object? (451 N)
    b. What is the force of friction acting on the object? (81 N)
    c. What is the net force acting on the object? (119 N)

6. A box is being pulled across the floor at a constant velocity with an applied force of 250 N. The coefficient of kinetic friction is 0.16. What is the mass of the box? (159 kg)

7. A 37 kg crate is pulled at a constant velocity with an applied force of 145 N. Calculate the coefficient of kinetic friction. (0.40)

8. A 39 kg object is being pulled with an applied force of 133 N. The coefficient of kinetic friction is 0.25. What is the net force acting on the object? (37 N)

9. A 42 kg box is moved with a net force of 52 N. The applied force necessary is 210 N. What is the coefficient of kinetic friction? (0.38)

10. A sled has a weight of 166 N and is being pulled with a net force of 27 N. The coefficient of kinetic friction is 0.24. What is the applied force? (67 N)

11. A 6.2 kg book is pressed against the wall. The coefficient of static friction between the book and wall is 0.16. Calculate the minimum applied force necessary to keep the book from slipping down. (380 N)

12. A 14.7 kg box is pressed up against the wall using an applied force of 600 N. For the box not to fall, calculate the minimum coefficient of static friction necessary between the wall and the box. (0.24)

13. A 22 kg box held up against a wall. The coefficients of friction are μ_s = 0.39 and μ_k = 0.27. Calculate the minimum applied force necessary to support the box on the wall. After a period of time the applied force is 300 N, calculate the vertical net force on the crate. (554 N; 135 N [down])

14. A 15 kg box is pressed on a wall. The net force acting on the box is 294 N [down] when the horizontal pushing force is 275 N. Calculate the coefficient of kinetic friction. (0.32)

5.1 Section Review

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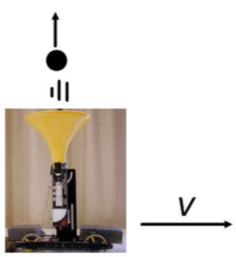
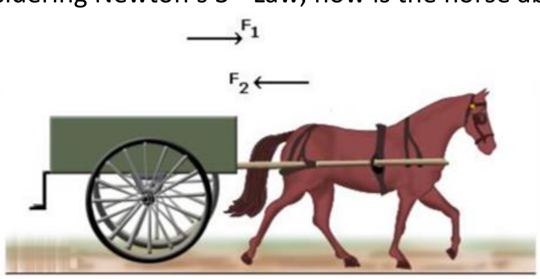
1. K/U State Newton's first law in two different ways.
2. C Identify the two basic situations that Newton's first law describes and explain how one statement can cover both situations.
3. MC A stage trick involves covering a table with a smooth cloth and then placing dinnerware on the cloth. When the cloth is suddenly pulled horizontally, the dishes "magically" stay in position and drop onto the table.
   (a) Identify all forces acting on the dishes during the trick.
   (b) Explain how inertia and frictional forces are involved in the trick.
4. K/U Give an example of an unusual frame of reference used in a movie or a television program. Suggest why this viewpoint was chosen.
5. K/U Identify the defining characteristic of inertial and non-inertial frames of reference. Give an example of each type of frame of reference.
6. C In what circumstances is it necessary to invoke ficticious forces in order to explain motion? Why is this term appropriate to describe these forces?
7. Is the Earth an inertial frame of reference? If not, why are we still able to accurately use Newton's laws of motion?
8. Give two examples of objects that cannot be analyzed with Newtonian mechanics.
9. Is the ball in the image below likely to land in the funnel if the cart is maintaining a constant velocity? What about if the cart has a constant acceleration? Provide an explanation for your answers.



10. Describe how the floor pushes you forward and that you do not push the floor.
11. How could an astronaut lost in space with a fire extinguisher move around?
12. Considering Newton's 3rd Law, how is the horse able to move the cart?



13. Describe how Newton's 3rd Law applies to rocket launches.

1. A towrope is used to pull a 1750 kg car across a flat surface, giving it an acceleration of 1.35 m/s^2. What force does the rope exert? (F = 2360 N)

2. A racing car undergoes a uniform acceleration of 4.00 m/s^2. If the net force causing the acceleration is 3000 N, what is the mass of the car? (m = 750 kg)

3. A 5.2 kg bowling ball is accelerated from rest to a velocity of 12 m/s as the bowler covers 5.0 m of approach before releasing the ball. What force is exerted on the ball during this time? (F = 75 N)

4. A high jumper falling at a 4.0 m/s lands on foam pit and comes to rest compressing the pit 0.40 m. If the pit is able to exert an average force of 1200 N on the high jumper breaking the fall, what is the jumper's mass? (m = 60 kg)

5. When a 20 kg child steps off a 3.0 kg (initially) stationary skateboard with an acceleration of 0.50 m/s^2, with what acceleration will the skateboard travel in the opposite direction? – hint: apply Newton's third law (a = 3.3 m/s^2)

6. On Planet X, a 50 kg barbell can be lifted by only exerting a force of 180 N.
   a. What is the acceleration of gravity on Planet X? (a = 3.6 m/s^2)
   b. What minimum force is needed to lift this barbell on Earth? (F = 490 N)

7. An applied force of 20 N is needed to accelerate a 9.0 kg wagon at 2.0 m/s^2 along a sidewalk.
   a. How large is the frictional force? (F_f = 2.0 N)
   b. What is the coefficient of friction? (μ = 0.023)

8. A 2.0 kg brick has a sliding coefficient of friction of 0.38. What force must be applied to the brick for it to move at a constant velocity? (F_a = 7.5 N)

9. In bench pressing 100 kg, a weight lifter applies a force of 1040 N. How large is the upward acceleration of the weights during the lift? (a = 0.59 m/s^2)

10. An elevator that weighs 3 000 N is accelerated upward at 1.5 m/s^2. What force does the cable apply to give this acceleration? (F_a = 3460 N)

11. An 873 kg dragster, starting from rest, attains a speed of 26.3 m/s in 0.59 s.
    a. Find the average acceleration of the dragster during this time interval. (a = 44.6 m/s^2)
    b. What is the size of the average force on the dragster during this time interval? (F = 38 900 N)
    c. If the driver has a mass of 68 kg, what force does the seatbelt exert on the driver? (F = 3030 N)

12. The downward acceleration of a karate chop is –6500 m/s^2. If the mass of the forearm is 0.70 kg, what is the force exerted by the arm? (F = –4550 N)

13. A car with a mass of 1550 kg is driving on track initially going 10 m/s. The driver accelerates to 30 m/s in 10 s. What is the average force acting on the car during that time? (F = 3100 N)

14. A car has a mass of 710 Kg. It starts from rest and travels 40 m in 3.0 s. What is the average force acting on the car assuming a uniform acceleration? (F = 6300 N)

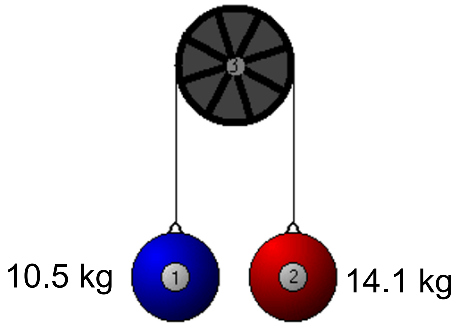
15. A force of –9000 N is used to stop a 1500 kg car traveling 20 m/s. What breaking distance is needed to bring the car to a halt? (d = 33 m)

16. A 65 kg diver jumps of a 10 m high platform.
    a. Find the swimmer's velocity the instant he reaches the water. (v = –14 m)
    b. The swimmer comes to a stop 2.0 m below the surface of the water. Calculate the net stopping force exerted by the water. (F = 3200 N)

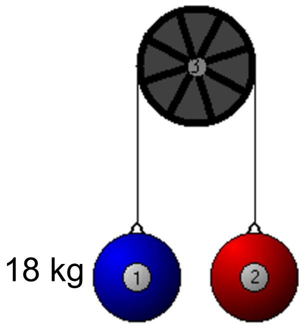
17. A 825 kg car goes from 62 m/s [E] to 25 m/s [W] in 9.5 s.
    a. Calculate the average force acting on the car. (-7555 N)
    b. Calculate the final position of the car assuming the initial position is zero. (175 m [E])
    c. Assuming a constant acceleration, calculate the instantaneous velocity 21 seconds (from when the acceleration first started).
    d. Calculate the final position of the car from part ***c***.
    e. Calculate the displacement of the car from the result of part ***b*** to ***d***.

Connected Masses Practice

Calculate the acceleration of the masses and the magnitude of tension in the string in the diagram below.



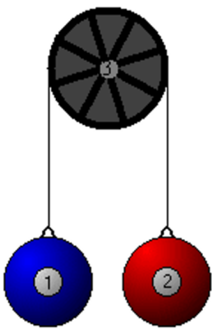
Given the information in the diagram, calculate M_2 and the magnitude of tension in the string.



$|\vec{a}| = 4.9\ m/s^2$ ↓

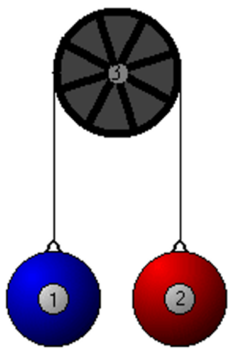
A counter weight of 13.5 kg is used to help a person of mass 62.4 kg do chin ups.

1. Calculate the force applied by the person if he accelerates at $1.9\ m/s^2$.
2. Calculate the magnitude of tension in the wire.

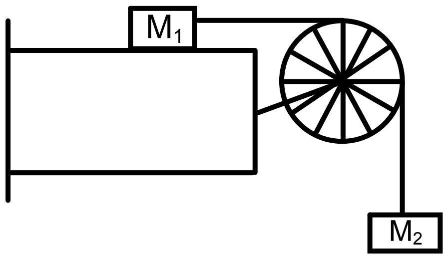


Connected Masses Practice

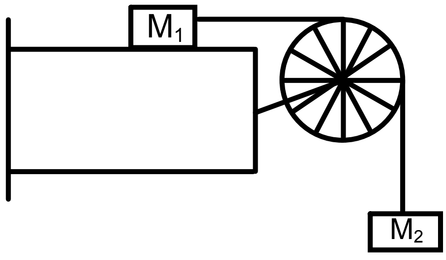
Suppose the maximum mass a person can lift is 21 kg. A counterbalance is set up to help that person lift other objects. Calculate the minimum mass of the counter weight for the person to lift a 60 kg object with an acceleration of 1.75 m/s^2



Calculate the acceleration of the masses if M_1 = 5.2 kg, M_2 = 4.5 kg, and μ_k = 0.22. Then calculate the tension in the wire.



Calculate the mass necessary to hang over the pulley that will result in an acceleration of masses at 2.3 m/s^2 if M_1 = 7.3 kg and μ_k = 0.15. Then calculate the tension in the wire.



Physics 122: Vector Components

1. **C** Explain how to resolve a vector.
2. **C** What use is the Pythagorean theorem in resolving vectors?
3. **K/U** Draw examples of velocity vectors for the following cases:
   (a) the x- and y-components are both positive
   (b) the x-component is positive and the y-component is negative
   (c) the x-component is negative and the y-component is positive
   (d) the x-component is zero and the y-component is negative
4. **K/U** Consider a standard x–y-coordinate system. In which quadrant(s) does a vector have:
   (a) two positive components?
   (b) two negative components?
   (c) one positive and one negative component?

Resolving Vectors

1. How fast must a truck travel to stay beneath an airplane that is moving 105 km/h at an angle of 25° to the ground?
2. What is the magnitude of the vertical component of the velocity of the plane in item 1?
3. A truck drives up a hill with a 15° incline. If the truck has a constant speed of 22 m/s, what are the horizontal and vertical components of the truck's velocity?
4. What are the horizontal and vertical components of a cat's displacement when the cat has climbed 5 m directly up a tree?

1. Calculate the horizontal, *East*, and vertical, *North*, components of the following vectors (East and North are the positive directions).
   a. F_a = 248 N [E38°N]
   b. v = 65.6 m/s [W56°N]
   c. a = 38.4 m/s^2 [E81°S]
   d. F_T = 614 N [W22°S]
   e. Δx = 1587 m [E33°N]
   f. a = 36.9 m/s^2 [W54°S]

2. Given the components of the following vectors, calculate the resultant vector.
   a. F_E = 21.4 N, F_N = 38 N
   b. v_E = -33 m/s, v_N = 16 N
   c. F_E = 87 N, F_N = -66 N
   d. a_E = -18 m/s^2, a_N = -9.5 m/s^2
   e. v_E = 45 m/s, v_N = - 77 m/s
   f. v_E = -159 m/s, v_N = 121 m/s

3. Given the following three vectors, perform the indicated calculation. **A** = 35 m [E25°N], **B** = 61 m [W66°N], and **C** = 50 m [E76°S]
   a. **A** + **B**
   b. **A** + **C**
   c. **C** – **A**
   d. 2**B** – 3**C**
   e. **A + B + C**
   f. **A – B + C**
   g. **-2A + 5C**

Physics 122/Physics 121
Vectors – Perpendicular Components

1. The velocity of an ambulance is 28 m/s, 35^o N of E. What are the components of the ambulance's velocity? (The horizontal component is 23 m/s E and the vertical component is 16 m/s N.)

2. The displacement of a plane is 289 km, 31.0^o S of W. What are the components of the plane's displacement? (The horizontal and vertical components of the plane's displacement are 248 km W and 149 km S respectively.)

3. A cannon ball is shot from a cannon with a velocity of 350 m/s at angle of 55.0^o to the ground. Fizzicks calculates the magnitude of the horizontal component of the cannon ball's velocity to be 287 m/s. Is Fizzicks correct? (No. The magnitude of the horizontal component is 201 m/s. Fizzicks actually calculated the vertical component of the cannon ball's velocity. Perhaps Fizzicks should have taken the time to draw a sketch of the situation :)

4. Three forces act simultaneously on point P: the first force is 12 N north, the second force is 18 N west and the third force is 15 N, 20^o north of east. Calculate the resultant force. (The resultant force is 18 N, 77^o N of W.)

5. You kick a soccer ball 6.22 m N. An opponent kicks it 5.10 m in a direction 28.2^o S of W and then one of your teammates kicks it 2.08 m in a direction 56.0^o N of W. What is the resultant displacement of the ball? (The resultant displacement of the ball is 7.91 m, 44.4^o N of W.)

6. You are giving your younger brother driving lessons in an empty parking lot on a Sunday afternoon. He drives at 24 m/s in a direction 75^o N of E, then 35 m/s S and 58 m/s 64^o S of W before you tell him to stop. What is the resultant velocity? (The resultant velocity is 67 m/s, 73^o S of W.)

Physics 122: Applications of Vectors

1. If **A** = 35 m [E25°N], **B** = 43 m [E74°S], and **C** = 25 m [W45°S] Find:
    a. A + B
    b. 4A + 3C
    c. A – B
    d. 3C – 2B

2. What is the resultant displacement of 25 m [N], 18 m [S], and 12 m [E]? What is the average velocity if the trip took 37 seconds? {d = 13.9 m [E30°N]; v = 0.376 m/s [E30°N]}

3. Find the acceleration of an object that goes from 15.0 m/s [S] to 15 m/s [W] in 2.0 seconds. {a = 10.6 m/s^2 [W45°N]}

4. A car is initially moving 7.5 m/s [N]. After 3.0 seconds it is moving 10.0 m/s [E40°N]. Calculate:
    a. The acceleration. {a = 2.57 m/s^2 [E8.1°S]}
    b. The velocity after 6.0 s if the acceleration remains constant. {v_f = 16.2 m/s [E19°N]}

5. What is the acceleration of a car that changes its velocity from 20.0 m/s [N] to 20.0 m/s [E45°N] in a time of 5.00 s? {a = 3.06 m/s^2 [E23°S]}

6. A 500 kg airplane in initially flying 200 m/s [E45°N] turns such that after 7.00 s the velocity is 140 m/s [E]. Find:
    a. The acceleration. {a = 20.2 m/s^2 [W89°S]}
    b. The average force acting during the turn. {F = 10100 N [W89°S]}

7. What is the force required to change to change the velocity of a 1200 kg car from 26.0 m/s [E] to 30.0 m/s [E30°S] in a time of 5.00 seconds? {F = 3600 N [S]}

8. Three forces act simultaneously on an object. One force is 10.0 N [N], the second is 15 N [W], and the third is 15.0 N [E60°N]. Determine the net force? {F = 24.2 N [W72°N]}

9. On a boat you are sailing 6.5 m/s [E20°S]. A gust of wind provides an acceleration equal to 2.1 m/s^2 [E60°N] for 18 seconds.
    a. What is your velocity after the 18 seconds? {v = 39.4 m/s [E51°N]}
    b. What is the displacement in during that time? {d = 378 m [E42°N]}

10. A glider is flying 9.2 m/s [E25°N]. A gust of wind changes the glider's trajectory to 11 m/s [E14°S] in 7.9 seconds.
    a. What was the acceleration of the glider? {a = 0.88 m/s^2 [E70°S]}
    b. What was the displacement of the glider during that time? {d = 75 m [E3.7°N]}
    c. What was the average force if the glider has a mass of 55 kg? {F = 48 N [E70°S]]}

11. You are 37 km [W20°N] from Miramichi and must move to a position 15 km due West of the city. What displacement is required?{d = 23 km [E31°S]}

Physics 122: Applications of Vectors

12. A coast guard boat (with a helicopter) is 75 km [E67°N] from port. A distress call comes in from a fishing vessel located 93km [E26°S] from port.
    a. How far is the fishing boat from the coast guard boat? {d = 122 km [E64°S]}
    b. What is the minimum velocity of the helicopter to reach the boat in distress within 0.5 hours? {v = 244 km/s [E64°S]}

13. On a day when the wind is 80.0 km/h [E], an airplane is aimed [E65°N] and flown at a speed of 320 km/h. How far and in which direction will the plane fly in 0.33 hours? {d = 119 km [E53°N]}

14. A boat's heading is directly across a river at 5.0 km/h. The river is flowing east at 3.0 km/h.
    a. What is the velocity of the boat relative to someone standing on the dock where the boat departed? {v = 5.8 km/h [E53°N]}
    b. How far down stream does it land if the trip takes 0.5 h? {d_E = 1.5 km}
    c. How wide is the river? {d_N = 2.5 km}

15. On a day when the wind is blowing 70 km/h [W40°S] you wish to fly to a destination 830 km [E60°S] in 1.5 hours. What heading and speed should you fly your plane? {v = 545 km/h [E53°S]}

16. A river has a current of 6.0 m/s [E]. What speed must a boat be able to travel to go straight across the river when it is aimed 75° upstream? {v = 23.2 m/s}

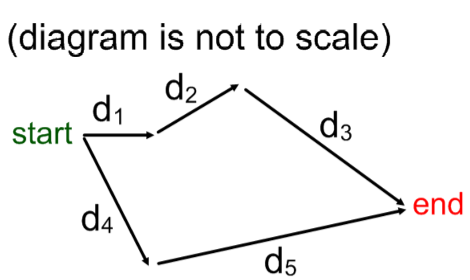
17. It is a distance of 500 m straight east to get across a river. The river has a current of 3.7 m/s due south. You have a boat that can travel 10 m/s.
    a. Which way should you aim your boat to get directly across the river? {E22°N}
    b. How long will it take to cross the river? {54 s}

18. A boat can travel 7.5 m/s. Which way must it be aimed to travel directly across a river with a current of 3.6 m/s? {29° upstream}

19. A Canadian submarine is 185 km [E22°S] of Halifax. An enemy sub is spotted 425 km [E67°N] of Halifax. The enemy is heading directly towards Halifax at 45 km/h. What minimum velocity is required for the Canadian submarine to intercept the enemy sub 200 km from Halifax? {v_{sub} = 54 km/h [W70°N]}

20. An object is moving 35 m/s [E40°N] and undergoes an acceleration of 3.7 m/s^2 [W10°N]. How much time is required for the displacement to be 609 m [W72°N]? {t = 20 s}

21. Given the information below, solve for the missing vector:



d_1 = 7.5 m [E]

d_2 = 12 m [E25N]

d_3 = ?

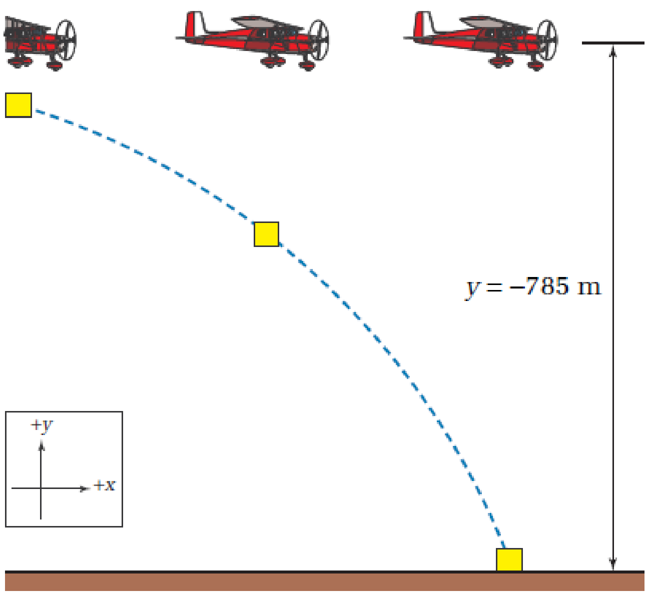
d_4 = 24 m [E55S]

d_5 = 36 m [E20N]

Physics 122: Projectile Problems

Chapter 11 Pg 536 – 537

1. An airplane is dropping supplies to northern villages that are isolated by severe blizzards and cannot be reached by land vehicles. The airplane is flying at an altitude of 785 m and at a constant horizontal velocity of 53.5 m/s. At what horizontal distance before the drop point should the co-pilot drop the supplies so that they will land at the drop point? (Neglect air friction.)



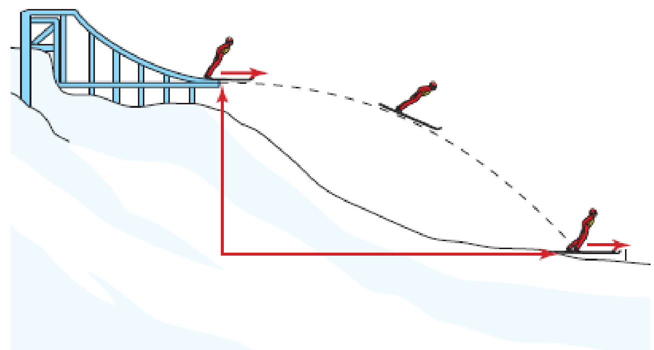
4. An archer shoots an arrow toward a target, giving it a horizontal velocity of 70.1 m/s. If the target is 12.5 m away from the archer, at what vertical distance below the point of release will the arrow hit the target? (Neglect air friction.)

5. In a physics experiment, you are rolling a golf ball off a table. If the tabletop is 1.22 m above the floor and the golf ball hits the floor 1.52 m horizontally from the table, what was the initial velocity of the golf ball?

6. As you sit at your desk at home, your favourite autographed baseball rolls across a shelf at 1.0 m/s and falls 1.5 m to the floor. How far does it land from the base of the shelf?

2. A cougar is crouched on the branch of a tree that is 3.82 m above the ground. He sees an unsuspecting rabbit on the ground, sitting 4.12 m from the spot directly below the branch on which he is crouched. At what horizontal velocity should the cougar jump from the branch in order to land at the point at which the rabbit is sitting?

3. A skier leaves a jump with a horizontal velocity of 22.4 m/s. If the landing point is 78.5 m lower than the end of the ski jump, what horizontal distance did the skier jump? What was the skier's velocity when she landed? (Neglect air friction.)



7. A stone is thrown horizontally at 22 m/s from a canyon wall that is 55 m high. At what distance from the base of the canyon wall will the stone land?

8. A sharpshooter shoots a bullet horizontally over level ground with a velocity of 3.00×10^2 m/s. At the instant that the bullet leaves the barrel, its empty shell casing falls vertically and strikes the ground with a vertical velocity of 5.00 m/s.
   - (a) How far does the bullet travel?
   - (b) What is the vertical component of the bullet's velocity at the instant before it hits the ground?

1. Fizzicks jumps off a diving board with a horizontal velocity of +3.1 m/s and lands in the water 1.8 s later. How high was the diving board and how far from the edge of the board did he land? (16 m, 5.6 m)

Physics 122: Projectile Problems

2. A ball bearing traveling with constant speed rolls off a lab bench that is 0.928 m high. If it hits the ground 0.422 m from the edge of the bench, how fast was the ball bearing rolling across the table initially? (0.970 m/s)

3. Johnny shoots a stone horizontally with a velocity of +25 m/s from his slingshot while standing on the roof of a building on his father's farm. When he dropped an identical stone from the same spot, it took 1.85 s to hit the ground. What was the height of the building? (16.8 m)

4. A stone is thrown horizontally from a cliff 15.0 m high.
   a) The initial velocity is +24.0 m/s. How far from the base of the cliff does the stone strike the ground? (42.0 m)
   b) What is the final vertical velocity of the stone just before the stone hits the ground? (-17.1 m/s)
   c) Calculate the velocity of the stone just before the stone hits the ground? (29.5 m/s, 35.5° S of E)

5. A cannonball is fired from a cannon. If the initial horizontal and vertical components of the velocity are +32 m/s and +27 m/s respectively, at what angle was the cannon ball launched and at what speed was it fired? (40° to the horizontal, 42 m/s) How long will the cannonball be in the air? (5.5 s)

6. A projectile fired at an angle remains in the air for 8.42 s after it is fired. The initial horizontal component of its velocity is +150 m/s.
   a) How far forward did the projectile move forward before it hit the ground? (1.26×10^3 m)
   b) How long after being fired did it reach its maximum height? (4.21 s)

7. A ball is thrown from the top of one building toward the wall of a second taller building 15.2 m away. The ball is thrown with an initial velocity of 6.10 m/s at an angle of 40.0° to the horizontal. How far below its original position does the ball hit the second building? (39.1 m below its original position)

8. A baseball player throws a ball from center field to home plate with a velocity of 35.0 m/s at an angle of 30.0° with the ground. Assuming the ball is caught at the same height at which it was thrown; calculate the horizontal distance traveled by the ball before it is caught. (108 m)

9. A projectile is fired with an initial velocity of 75.2 m/s at an angle of 34.5° above the horizontal along a long flat firing range. Determine the
   a) maximum height reached by the projectile (92.7 m)
   b) range of the projectile (539 m)
   c) speed of the projectile 1.50 s after being fired (68.0 m/s)

10. A hockey player hits a puck with his hockey stick and the puck is launched at an angle of 45° to the ice surface. The puck hits the ice 35 m down the length of the rink. Find the velocity of the puck when it left the hockey stick. (19 m/s at 45° to the horizontal)

11. A no good thief steals Mrs. Corlette's purse and makes a run for it. Mrs. Corlette, being puny and weak, calls for help. Mr. MacDonald sees this happen and gets angry, turns green, muscles rip his shirt apart, and he wants to smash. Mr. MacDonald becomes the *Phulk* and grabs a nearby car at the spot the purse was stolen and throws it East at an angle of 45° to the horizontal. The instant the doomed car left the Phulk's hand the thief has run for 8.7 seconds at a constant velocity of 3.2 m/s [E]. With what initial speed does the Phulk have to throw the car so that it hits the running thief? (19 m/s)

12. A cannonball has a muzzle speed of 35 m/s. If the cannon ball is launched from the ground then what is the maximum range of the cannonball? (125 m)

13. Suppose the cannon from #12 were placed on a 17 m high castle wall. What is its new maximum range? (140 m)

14. How high should the cannon from #12 be placed to pulverize advancing orcs that are 200 m away; assuming that 200 m is the maximum range of the cannon? (120 m)

15. The King, fed up with stupid, ugly orcs, wants to increase the maximum range of his cannons to 500 m. The cannons are placed 25 m up in the castle. What muzzle speed should the cannonballs have? (68.3 m/s)

16. MHR Page 549 PP #14. Go ahead, try it. I double-dog dare ya.

PRACTICE PROBLEMS

Chapter 11 Pg 543

9. While hiking in the wilderness, you come to the top of a cliff that is 60.0 m high. You throw a stone from the cliff, giving it an initial velocity of 21 m/s at 35° above the horizontal. How far from the base of the cliff does the stone land?

10. A batter hits a baseball, giving it an initial velocity of 41 m/s at 47° above the horizontal. It is a home run, and the ball is caught by a fan in the stands. The vertical component of the velocity of the ball when the fan caught it was –11 m/s. How high is the fan seated above the field?

11. During baseball practice, you go up into the bleachers to retrieve a ball. You throw the ball back into the playing field at an angle of 42° above the horizontal, giving it an initial velocity of 15 m/s. If the ball is 5.3 m above the level of the playing field when you throw it, what will be the velocity of the ball when it hits the ground of the playing field?

12. Large insects such as locusts can jump as far as 75 cm horizontally on a level surface. An entomologist analyzed a photograph and found that the insect's launch angle was 55°. What was the insect's initial velocity?

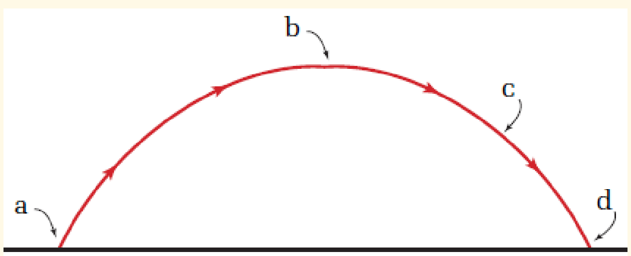
11.1 Section Review

1. K/U Projectiles travel in two dimensions at the same time. Why is it possible to apply kinematic equations for one dimension to projectile motion?

2. K/U How does the analysis of projectiles launched at an angle differ from the analysis of projectiles launched horizontally?

3. C Explain why time is a particularly significant parameter when analyzing projectile motion.

4. C What can you infer about the velocity at each labelled point on the trajectory in this diagram?



5. C Imagine that you are solving a problem in projectile motion in which you are asked to find the time at which a projectile reaches a certain vertical position. When you solve the problem, you find two different positive values for time that both satisfy the conditions of the problem. Explain how this result is not only possible, but also logical.

6. K/U What properties of projectile motion must you apply when deriving an equation for the maximum height of a projectile?

7. K/U What properties of projectile motion must you apply when deriving an equation for the range of a projectile?

8. I Suppose you knew the maximum height reached by a projectile. Could you find its launch angle from this information alone? If not, what additional information would be required?

Momentum, Impulse, and Conservation of Momentum

PRACTICE PROBLEM

Momentum: Chapter 5 pg. 197

29. Determine the momentum of the following objects.

(a) 0.250 kg baseball travelling at 46.1 m/s[E]

(b) 7.5×10^6 kg train travelling west at 125 km/h

(c) 4.00×10^5 kg jet travelling south at 755 km/h

(d) electron (9.11×10^{-31} kg) travelling north at 6.45×10^6 m/s

PRACTICE PROBLEMS

Impulse: Chapter 5 pg. 200

30. A sledgehammer strikes a spike with an average force of 2125 N[down] over a time interval of 0.0205 s. Calculate the impulse of the interaction.

31. In a crash test, a car strikes a wall with an average force of 1.23×10^7 N[S] over an interval of 21.0 ms. Calculate the impulse.

32. In a crash test similar to the one described in problem 31, another car, with the same mass and velocity as the first car, experiences an impulse identical to the value you calculated in problem 31. However, the second car was designed to crumple more slowly than the first. As a result, the duration of the interaction was 57.1 ms. Determine the average force exerted on the second car.

PRACTICE PROBLEMS

Impulse & Momentum Theorem: Chapter 5 pg. 203

33. The velocity of the serve of some professional tennis players has been clocked at 43 m/s horizontally. (Hint: Assume that any vertical motion of the ball is negligible and consider only the horizontal direction of the ball after it was struck by the racquet.) If the mass of the ball was 0.060 kg, what was the impulse of the racquet on the ball?

34. A 0.35 kg baseball is travelling at 46 m/s toward the batter. After the batter hits the ball, it is travelling 62 m/s in the opposite direction. Calculate the impulse of the bat on the ball.

35. A student dropped a 1.5 kg book from a height of 1.75 m. Determine the impulse that the floor exerted on the book when the book hit the floor.

5. MC A bungee jumper jumps from a very high tower with bungee cords attached to his ankles. As he reaches the end of the bungee cord, it begins to stretch. The cord stretches for a relatively long period of time and then it recoils, pulling him back up. After several bounces, he dangles unhurt from the bungee cord (if he carried out the jump with all of the proper safety precautions). If he jumped from the same point with an ordinary rope attached to his ankles, he would be very severely injured. Use the concept of impulse to explain the difference in the results of a jump using a proper bungee cord and a jump using an ordinary rope.

Momentum, Impulse, and Conservation of Momentum

PRACTICE PROBLEMS

1D Conservation of Momentum: Chapter 7 pg.

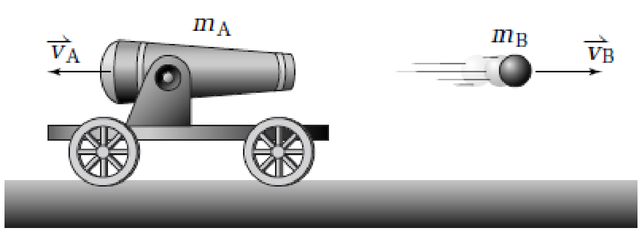
25. Claude and Heather are practising pairs skating for a competition. Heather (47 kg) is skating with a velocity of 2.2 m/s. Claude (72 kg) is directly behind her, skating with a velocity of 3.1 m/s. When he reaches her, he holds her waist and they skate together. At the instant after he takes hold of her waist, what is their velocity?

26. Two amusement park "wrecker cars" are heading directly toward each other. The combined mass of car A plus driver is 375 kg and it is moving with a velocity of +1.8 m/s. The combined mass of car B plus driver is 422 kg and it is moving with a velocity of –1.4 m/s. When they collide, they attach and continue moving along the same straight line. What is their velocity immediately after they collide?

PRACTICE PROBLEMS

1D Conservation of Momentum: Chapter 7 Pg 317

27. A 1385 kg cannon containing a 58.5 kg cannon ball is on wheels. The cannon fires the cannon ball, giving it a velocity of 49.8 m/s north. What is the initial velocity of the cannon the instant after it fires the cannon ball?



28. While you are wearing in-line skates, you are standing still and holding a 1.7 kg rock. Assume that your mass is 57 kg. If you throw the rock directly west with a velocity of 3.8 m/s, what will be your recoil velocity?

29. The mass of a uranium-238 atom is 3.95×10^{-25} kg. A stationary uranium atom emits an alpha particle with a mass of 6.64×10^{-27} kg. If the alpha particle has a velocity of 1.42×10^{4} m/s, what is the recoil velocity of the uranium atom?

7.3 Section Review

1. **C** Explain qualitatively how Newton's third law is related to the law of conservation of momentum.

2. **K/U** What is the difference between an internal force and an external force?

3. **K/U** How does a closed system differ from an isolated system?

4. **K/U** Under what circumstances is the change in momentum of a system equal to zero?

5. **K/U** Define and give an example of recoil.

6. **K/U** What is the difference between an elastic collision and an inelastic collision?

7. **C** Describe an example of an elastic collision and an example of an inelastic collision that were not discussed in the text.

8. **C** Given a set of data for a collision, describe a step-by-step procedure that you could use to determine whether the collision was elastic.

Momentum, Impulse, and Conservation of Momentum

PRACTICE PROBLEMS — 2D Conservation of Momentum: Chapter 10 pg. 209

Use both the scale diagram method and the method of components to solve each problem.

35. A 0.150 kg billiard ball (A) is rolling toward a stationary billiard ball (B) at 10.0 m/s. After the collision, ball A rolls off at 7.7 m/s at an angle of 40.0° clockwise from its original direction. What is the speed and direction of ball B after the collision?

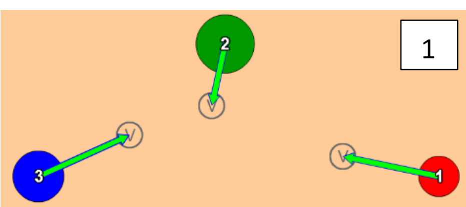
36. A bowling ball with a mass of 6.00 kg rolls with a velocity of 1.20 m/s toward a single standing bowling pin that has a mass of 0.220 kg. When the ball strikes the bowling pin, the pin flies off at an angle of 70.0° counterclockwise from the original direction of the ball, with a velocity of 3.60 m/s. What was the velocity of the bowling ball after it hit the pin?

37. Car A (1750 kg) is travelling due south and car B (1450 kg) is travelling due east. They reach the same intersection at the same time and collide. The cars lock together and move off at 35.8 km/h[E31.6°S]. What was the velocity of each car before they collided?

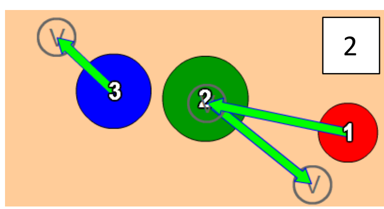
PRACTICE PROBLEMS — Explosions: Chapter 10 pg. 513

38. You accidentally dropped a 3.5 kg glass platter. Before it hit the floor, the motion was entirely in the vertical direction. When it hit the floor, it broke into three pieces and they all moved out in the plane of the floor. Imagine a coordinate system on the floor. Piece 1 had a mass of 1.3 kg and it moved off with a velocity of 1.8 m/s at an angle of 52° counterclockwise from the positive *x* axis. Piece 2 with a mass of 1.2 kg moved off with a velocity of 2.5 m/s at an angle of 61° clockwise from the negative *x* axis. Find the mass and the velocity of piece 3.

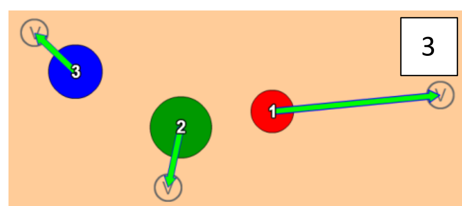
Below are three sequential images of objects that will undergo perfectly elastic collisions.



1. Before any collisions take place.

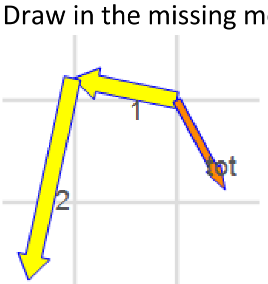


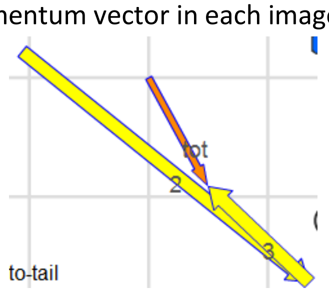
2. Ball #3 & #2 collided.

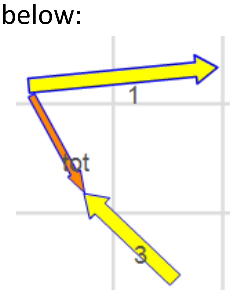


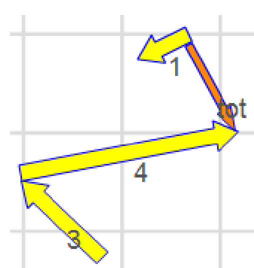
3. Ball #1 & #2 collided.

1. Ball #2 is more massive than ball #3; how is it possible that ball #2 can have a larger speed after they collide?
2. After all of the collisions, why is ball #1's speed mostly in the x-direction?
3. Is the momentum completely conserved in this situation from before any collisions to after two separate collisions? Explain your reasoning.
4. Suppose ball #1 flies off and hits an unseen ball (#4), how does that effect the total momentum of the system?
5. Draw in the missing momentum vector in each image below:





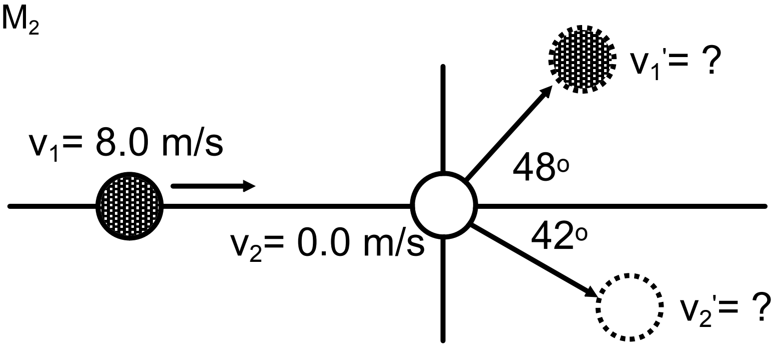




Conservation of Momentum in 2D - Practice

Physics 122

1) $M_1 = M_2$

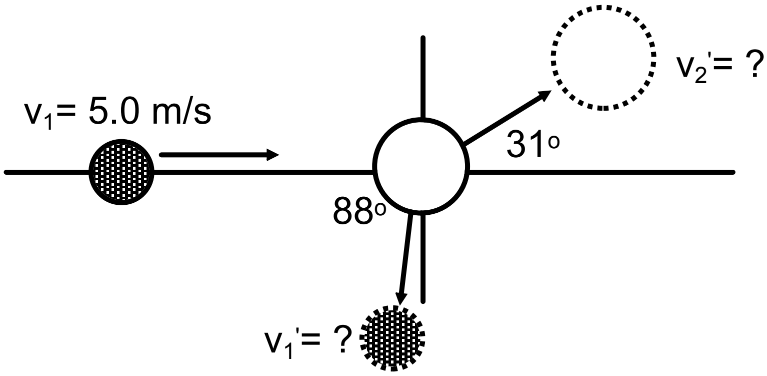


Answers

$v_1' = 5.3$ m/s

$v_2' = 6.0$ m/s

2) $M_1 = 1.5$ kg; $M_2 = 3.0$ kg

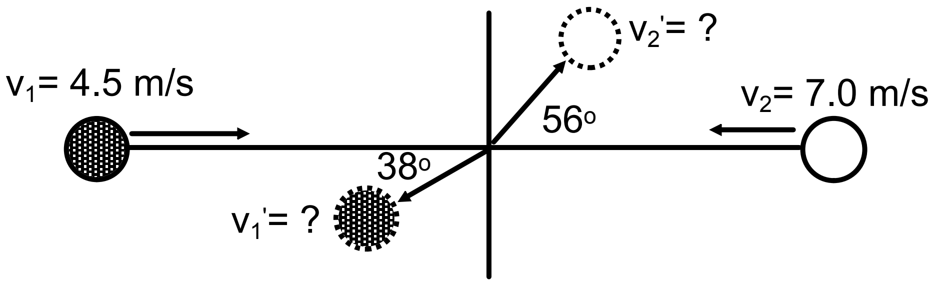


Answers

$v_1' = 2.9$ m/s

$v_2' = 2.9$ m/s

3) $M_1 = M_2$

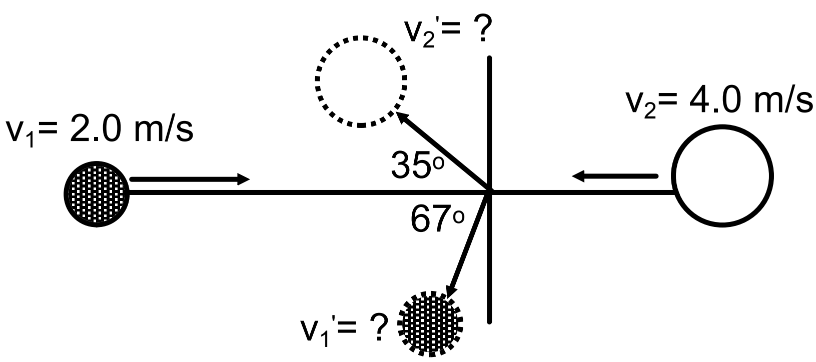


Answers

$v_1' = 6.7$ m/s

$v_2' = 5.0$ m/s

4) $M_1 = 2.0$ kg; $M_2 = 5.0$ kg



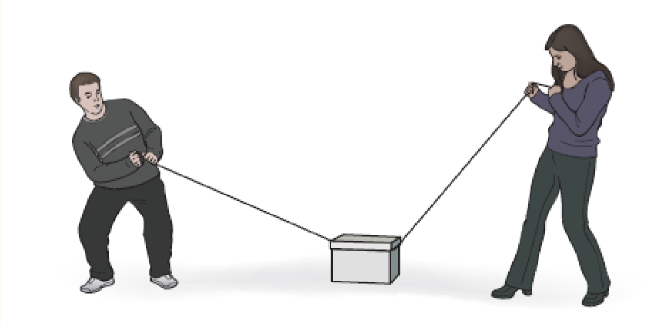
Answers

$v_1' = 4.6$ m/s

$v_2' = 3.0$ m/s

Equilibrium & Three Types of Force Problems

9. K/U A tall person and a short person pull on a load at different angles but with equal force, as shown.



(a) Which person applies the greater *horizontal* force to the load? What effect does this have on the motion of the load?

(b) Which person applies the greater *vertical* force to the load? What effect does this have on frictional forces? On the motion of the load?

PRACTICE PROBLEMS

Ch. 10 pg. 467

7. For each of the following combinations of forces, find the equilibrating force — the force that will make the vector sum equal to zero.

(a) $\vec{F}_1 = 154$ N[E22°S], $\vec{F}_2 = 203$ N[W74°N] What is $\vec{F}_3$?

(b) $\vec{F}_1 = 782$ N[E12°N], $\vec{F}_2 = 629$ N[W24°S] What is $\vec{F}_3$?

(c) $\vec{F}_1 = 48$ N[W81°N], $\vec{F}_2 = 61$ N[E63°N], $\vec{F}_3 = 78$ N[E15°S] What is $\vec{F}_4$?

8. Three young children are pulling on a stuffed animal toy. Amy is pulling with a force of 15 N[N58°E] and Buffy is pulling with a force of 18 N[S23°E]. With what force must Caitlin pull to prevent the toy from moving?

Physics 122/121

Force Problems - Type I

MHR - Chapter 5 - Page 174

17. A student pushes a 25 kg lawn mower with a force of 150 N. The handle makes an angle of 35° to the horizontal.

(a) Find the vertical and horizontal components of the applied force.

(b) Calculate the normal force supporting the lawn mower while it is being pushed.

(c) Calculate the net force propelling the mower if a frictional force of 85 N exists.

(d) Calculate the horizontal acceleration of the lawn mower. (Remember: Only part of the $F_{applied}$ is parallel to the direction of horizontal acceleration.)

a) 86 N, down
1.2 x 10^2 N, right
b) 3.3 x 10^2 N, up
c) 38 N, right
d) 1.5 m/s^2, right

MHR - Chapter 5 - Page 208

24. A toboggan with a mass of 15 kg is being pulled with an applied force of 45 N at an angle of 40° to the horizontal. What is the acceleration if the force of friction opposing the motion is 28 N?

0.43 m/s^2, right

25. A grocery cart is being pushed with a force of 450 N at an angle of 30.0° to the horizontal. If the mass of the cart and the groceries is 42 kg,

(a) Calculate the force of friction if the coefficient of friction is 0.60.

(b) Determine the acceleration of the cart.

a) 3.8 x 10^2 N, left
b) 0.23 m/s^2, right

MHR - Chapter 5 - Page 209

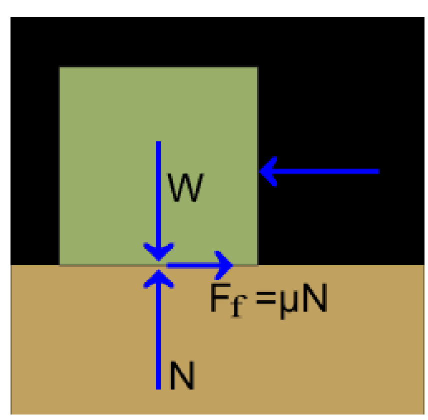
36. A 45.0 kg box is pulled with a force of 205 N by a rope held at an angle of 46.5° to the horizontal. The velocity of the box increases from 1.00 m/s to 1.50 m/s in 2.50 s. Calculate

(a) the net force acting horizontally on the box.

(b) the frictional force acting on the box.

(c) the horizontal component of the applied force.

(d) the coefficient of kinetic friction between the box and the floor.

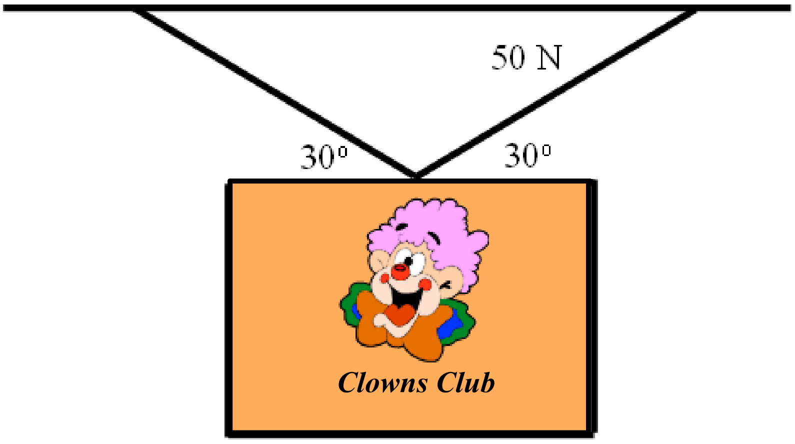


a) 9.0 N, right
b) 132 N, left
c) 141 N, right
d) 0.451

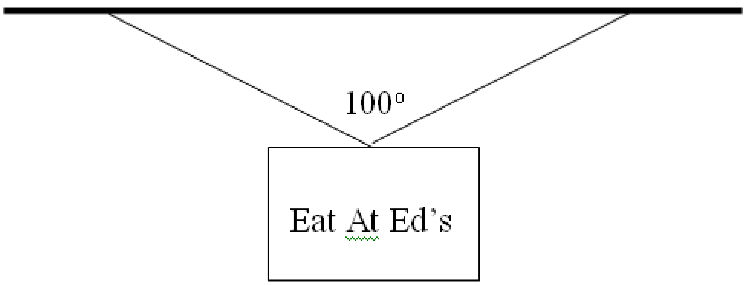
Physics 122/121

Handout - Static Equlibrium -Hanging Signs

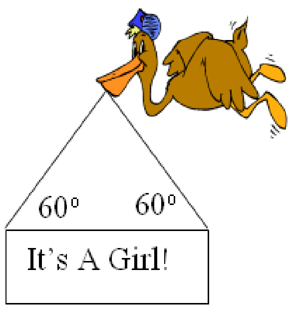
1. Find the magnitude of the weight of the clown's picture. (50 N)



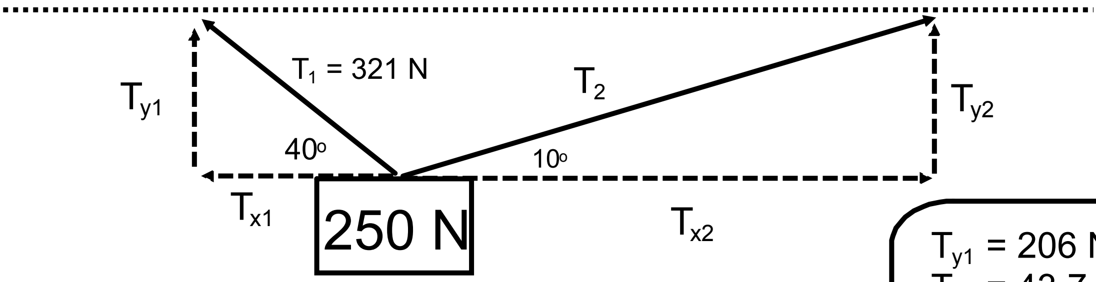
2. If the sign has a mass of 5.00 kg, what is the tension in the cables? (38 N)



3. The infamous stork announces good news. If the sign has a mass of 10 kg, then what is the force of tension in each cable? (57 N)



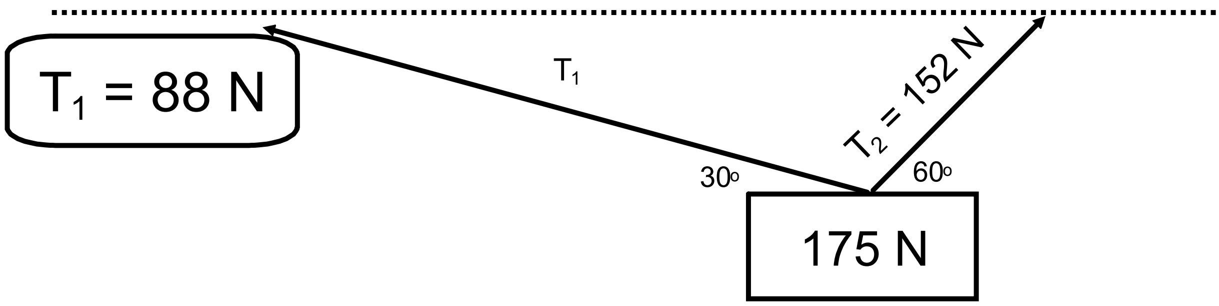
Determine T_{y1}, T_{y2}, T_2 , T_{x1}, and T_{x2} in the following sketch.



T_{y1} = 206 N
T_{y2} = 43.7 N
T_2 = 251 N
T_{x1} = 247 N (left)
T_{x2} = 247 N (right)

•

Determine T_1 in the following sketch.



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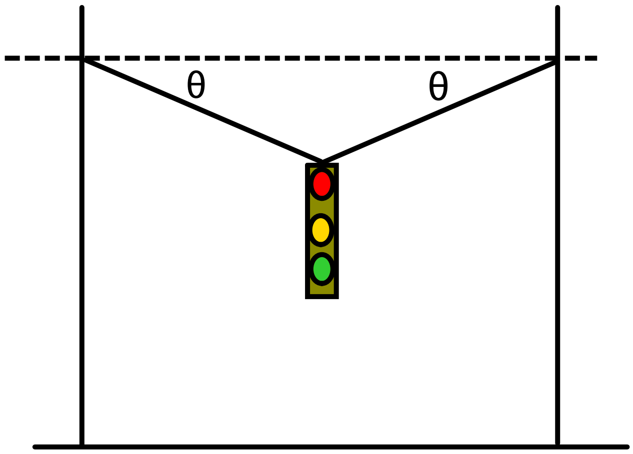
A traffic light is to be hung like in the diagram to the right (both angles are the same). The cable being used will break if their tension reaches 2100 N. What is the smallest angle that can be made if the lights have a mass of 110 kg? (Answer: 15°)



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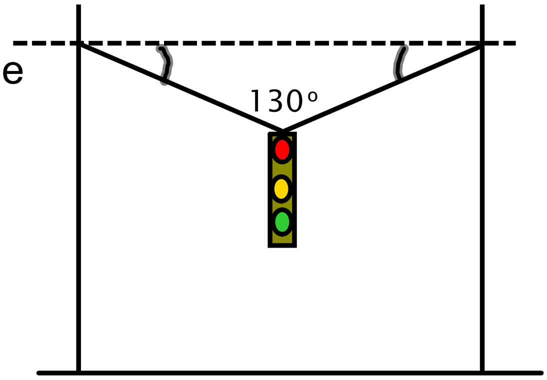
A traffic light is to be hung like in the diagram to the right. The cable being used will break if its tension reaches 1750 N. What is the largest mass that can be hung? (Answer: 151 kg)



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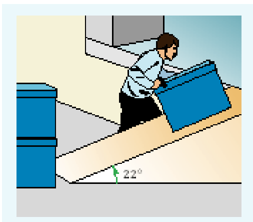
Sample Problems - Inclined Planes Handout

1. **A trunk weighing 562 N is resting on a plane inclined at** 30.0° from the horizontal. Find the components of the trunk's weight parallel and perpendicular to the plane.

2. A 562 N trunk is placed on a frictionless plane inclined at 30.0° from the horizontal. Find the magnitude and direction of the trunk's acceleration.

3. A worker places a large plastic waste container with a mass of 84 kg on the ramp of a loading dock. The ramp makes an angle of 22° with the horizontal. The worker turns to pick up another container before pushing the first one up the ramp. If the coefficient of static friction is 0.47, will the crate slide down the ramp?



4. A 1975 kg car is rolling down a hill inclined at an angle of 15°. What is the acceleration of the car? Neglect friction.

5. A skier coasts down a 3.5° slope at a constant speed. Find the coefficient of kinetic friction between the skis and the snow covering the slope.

6. You slide a 325 N trunk up a 20.0° inclined plane with a constant velocity by exerting a force of 211 N parallel to the inclined plane.

   a) What is the sum of your applied force, friction and the parallel component of the trunk's weight? Justify your answer.

   b) What is the magnitude and direction of the force of friction?

   c) What is the coefficient of friction?

Inclined Plane - Solutions

1. $F_{gx} = 281\ N$, $F_{gy} = 487\ N$

2. $a_{gx} = 4.905\ m/s^2$ down the ramp

3. No, $F_f > F_g$ $F_f = 359\ N$; $F_{gx} = 309\ N$

4. $a_x = 2.53\ m/s^2$

5. $\mu = 0.061$

6. a) $F_{netx} = 0\ N$

   b) $|F_f| = 100\ N$ down the ramp

   c) $\mu = 0.32$

Forces on an Incline Plane – Extra Practice

1. A 33 kg block is sliding down a 35° incline. The coefficient of kinetic friction is 0.13.
    a. Calculate the applied force up the ramp necessary so the block accelerates with a magnitude of 0.75 m/s^2 down the ramp.
    b. Recalculate to determine the applied force required to accelerate the block up the ramp at 0.75 m/s^2.

2. A 25 kg box is placed on a 33° incline. The coefficient of kinetic friction is 0.38. Calculate the acceleration of the box. (2.2 m/s^2 down the ramp)

3. An inclined ramp is to be used to slide down an object at a constant velocity. The coefficient of kinetic friction is 0.38. Calculate the angle required for this to happen.

4. A counterweight is used to slide an object up an inclined plane that makes a 42° angle with the horizontal. The counterweight has a mass of 40 kg and is suspended with a massless string and a friction less pulley. The coefficient of kinetic friction on the plane is 0.33. For the acceleration of the object not to exceed 0.22 m/s^2 up the ramp, what must be the minimum mass of the object?

5. A counterweight is used to slide an object up an inclined plane of 20°. The counterweight has a mass of 25 kg and is suspended with a massless string and a friction less pulley. The coefficient of friction on the plane is 0.19. What is the acceleration of a 16 kg object?

27. The block in the diagram has a mass of 145 g and the freely hanging object has a mass of 85 g. The coefficient of kinetic friction between the block and the ramp is 0.18. The ramp makes an angle of 22° with the horizontal.

(a) What will be the speed of the masses 2.5 s after they just start to move?

(b) What is the tension in the string while they are moving?

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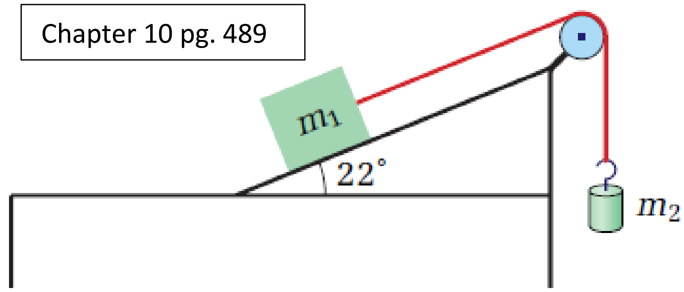
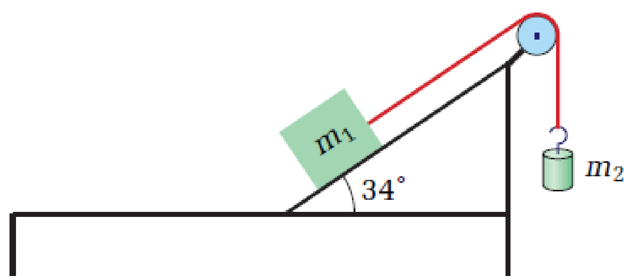


28. The block in the diagram has a mass of 725 g, and the hanging object has a mass of 595 g. The coefficient of static friction between the block and the inclined plane is 0.47, and the coefficient of kinetic friction is 0.12. The inclined plane makes an angle of 34° with the horizontal.

(a) What force directed up the incline would you have to apply to the block, to make the objects start to move?

(b) After the objects start to move, what will be their acceleration?

(c) What will be the tension in the string when the objects are moving?



Forces on an Incline Plane – Extra Practice

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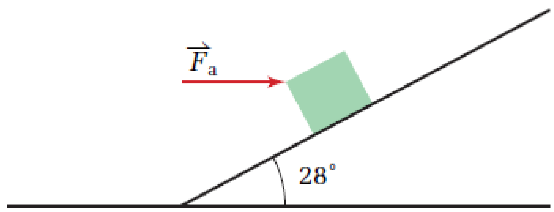
11. A 61 kg plastic container sits on a ramp.

(a) If the coefficient of static friction is 0.37, at what angle of the ramp would the container just start to slide?

(b) If the coefficient of kinetic friction is 0.18, what would be the acceleration of the container just after it started to slide?

13. A new worker in a warehouse is pushing an 85 kg crate up a 28° ramp. The coefficient of static friction is 0.46. Instead of pushing directly up the ramp, the worker is pushing directly horizontally as shown in the diagram.



(a) How hard does the worker have to push to start the crate moving up the ramp? (Hint: A component of the applied force is perpendicular to the ramp thus increasing the normal force.)

(b) An experienced worker stops and tells the new worker to kneel down a little and push directly up the ramp. How hard does the worker have to push to start the crate moving up the ramp from this position?

Three Types of Forces: Concept Review

1. A person is pushing a lawnmower. Her applied force is directed along the handle at a non-zero angle. Would the force of friction be increased or decrease as compared to only applying a horizontal force? Explain your answer.

2. A boy is pulling a sled at a constant velocity and the applied force is all in the horizontal direction. Describe how all of the forces (and possibly their components) would change when a taller boy pulls the same sled with the same applied force but at an increased angle to the horizontal. Is it possible for the sled to accelerate, remain at a constant velocity or not overcome friction and remain still? Explain your reasoning.

3. How is it changing the angle between the horizontal and a wire supporting a hanging mass will not change the y-component of the tension? How does the force of tension in the wire change as the angle changes?

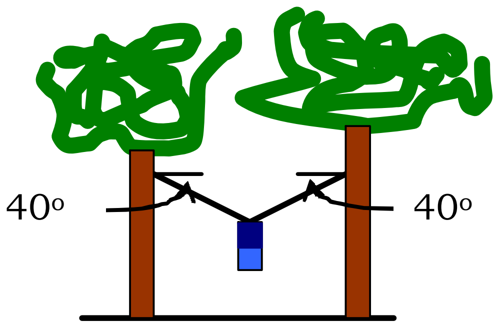
4. A mass sits still on an inclined ramp that makes a non-zero angle with the ground. Describe how all of the forces (and possible their components) would change as the ramp is lowered to an angle of zero. Is it possible for the mass to accelerate or move with a constant velocity? Explain your reasoning.

5. A very long, inclined ramp is at a high enough angle for a mass to slide down with a constant acceleration. Using the terminology of forces describe what would most likely happen to the motion of the mass as the ramp was slowly lowered to the ground.

Physics 122/121

Handout: Problems I, II and III

1. On a camping trip you stretch a rope between two trees and hang your backpack from the middle of it to keep it safe from bears. The mass of your backpack is 36.0 kg and each half of the rope makes an angle of 40.0° with the horizontal.
   a) Find the amount of weight supported by each half of the rope.
   b) Find the magnitude of the tension in each rope.



2. A 2.5 kg brick is pulled at a constant speed across a table by a cord that makes an angle of 20° with the horizontal. There is 7.0 N of force in the cord.
   a) Calculate the force of friction between the brick and the table.
   b) Calculate the magnitude of the normal force.

3. Joey moves a 26 kg wagon at a constant speed by pushing on the handle that makes an angle, theta, with the horizontal. Joey exerts a force of 54 N on the handle and the force of friction on the wagon is 34 N.
   a) Calculate the angle the handle of the wagon makes with the horizontal.
   b) What is the magnitude of the normal force acting on the wagon?

4. A 10 N block is held motionless on a frictionless inclined plane which makes an angle of 30° with the horizontal. What force would be needed to hold the block in position?

5. An object weighing 600 N is pulled up a frictionless incline at a constant speed using a rope. If the incline makes an angle of 42.0° with the horizontal, what is the magnitude of the force that is applied to the rope?

6. A 10 kg object, starting from rest, slides down a frictionless incline with a constant acceleration of 2.0 m/s^2. What angle does the incline make with the horizontal?

7. An object with a mass of 7.2 kg is allowed to slide from rest down an inclined plane. The plane makes an angle of 30° with the horizontal and is 65 m long. The coefficient of friction between the plane and the object is 0.45. What is the velocity of the object at the bottom of the plane?

8. A piano is accelerating down a ramp that is inclined at an angle of 38.5° above the horizontal. The acceleration is 4.62 m/s^2. What is the coefficient of friction between the piano and the ramp?

Answers

1. a)Each half of the rope supports half of the weight of the backpack, 176 N.
   b)The tension in each rope is 274 N.

2. a)The force of friction is 6.6 N, in a direction opposite to the motion of the brick.
   b)The magnitude of the normal force is 22 N.

3. a)The handle makes an angle of 51^o with the horizontal.
   b)The normal force is 3.0×10^2 N.

4. A 5.0 N force exerted up the incline would be needed.

5. It is 401 N.

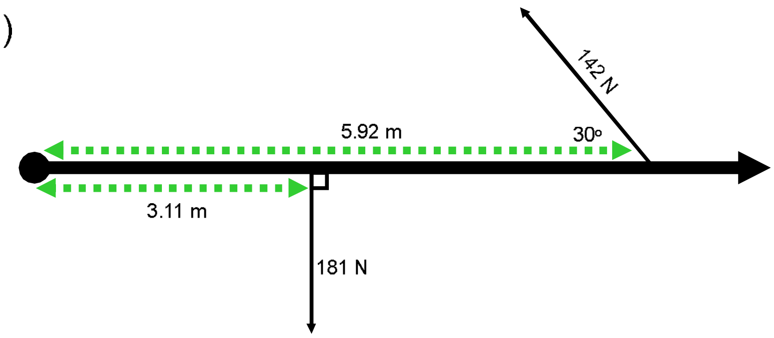
6. The incline makes an angle of 12^o.

7. The velocity of the object is –12 m/s.

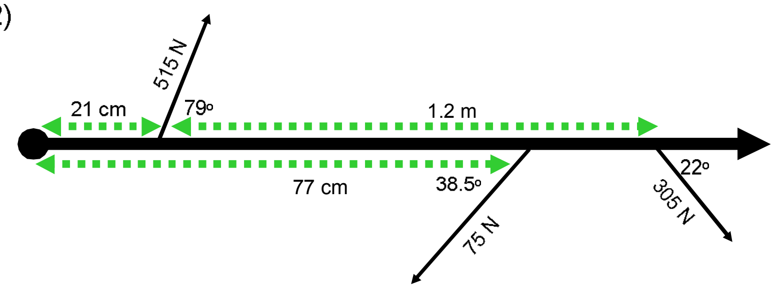
8. The coefficient of friction is 0.193.

Net Torque Practice

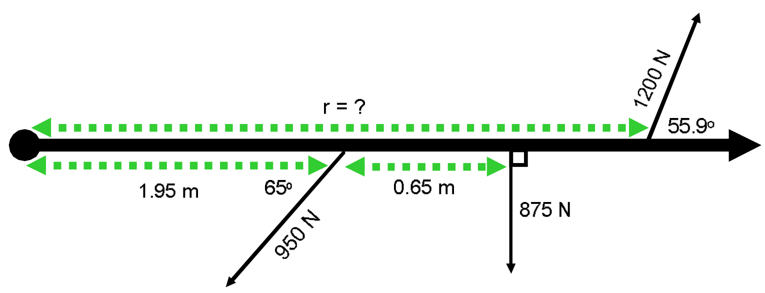
#1)



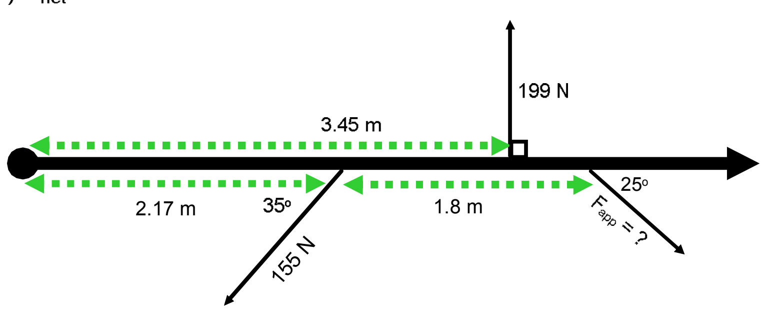
#2)



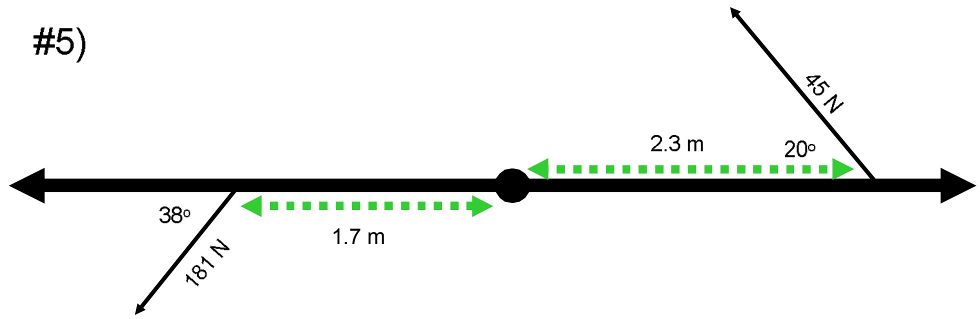
#3) τ_{net} = 0 Nm



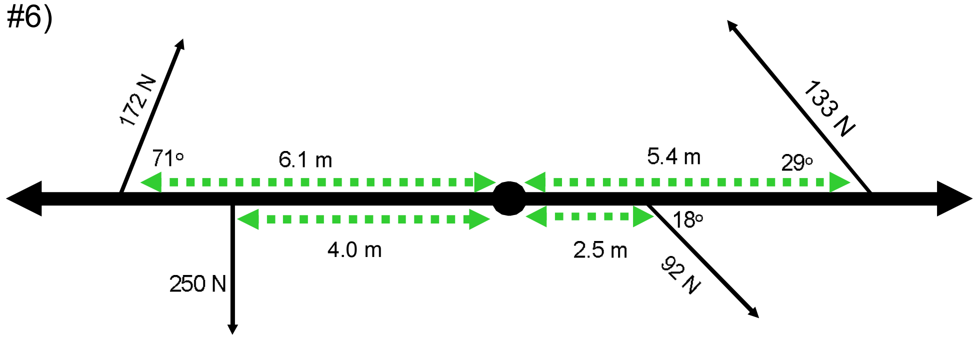
#4) τ_{net} = 0 Nm



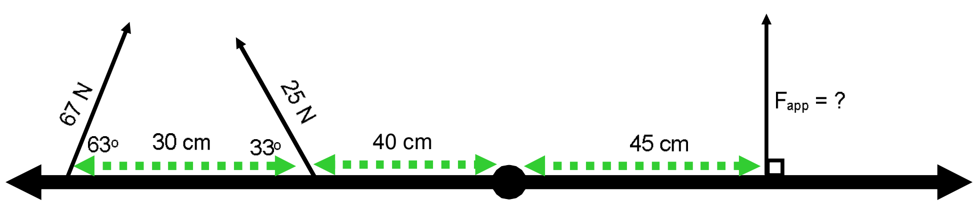
#5)



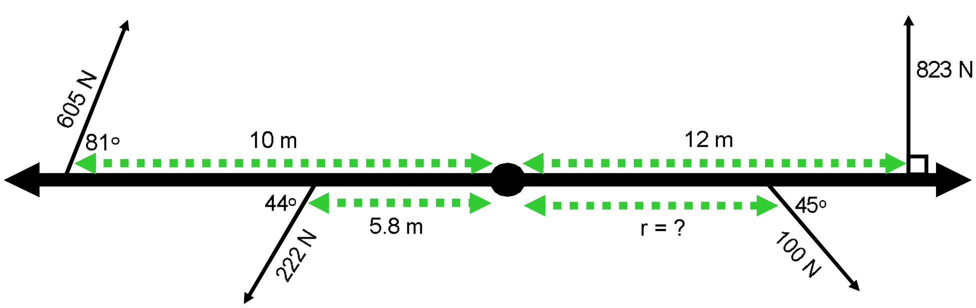
#6)



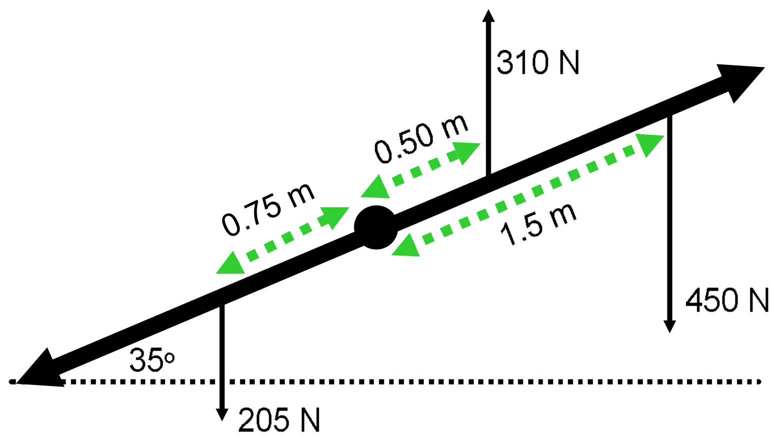
#7) $\tau_{net} = 0$ Nm



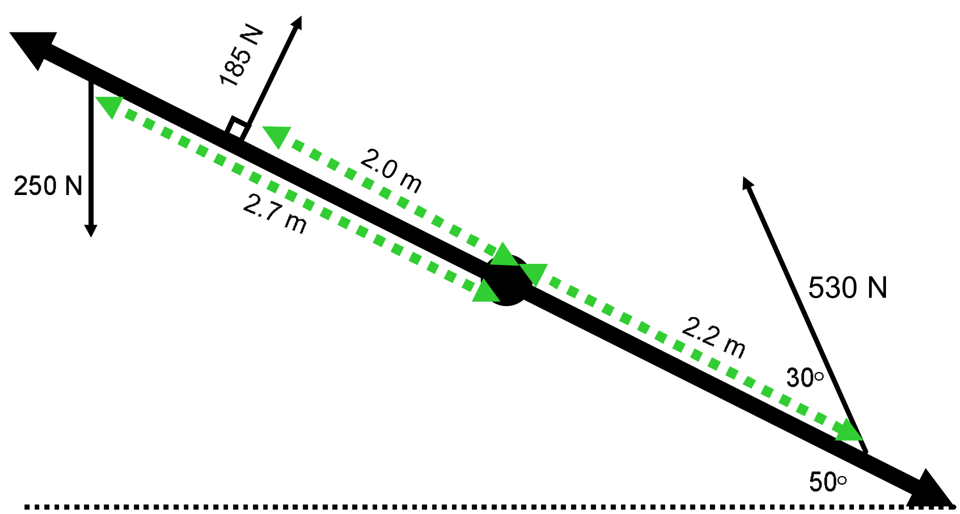
#8) $\tau_{net} = 0$ Nm



#9) All forces are perpendicular to the horizontal dashed line.



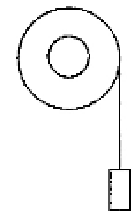
#10) Unless indicated, all forces are perpendicular to the horizontal dashed line.



Physics 122

Handout – Torque

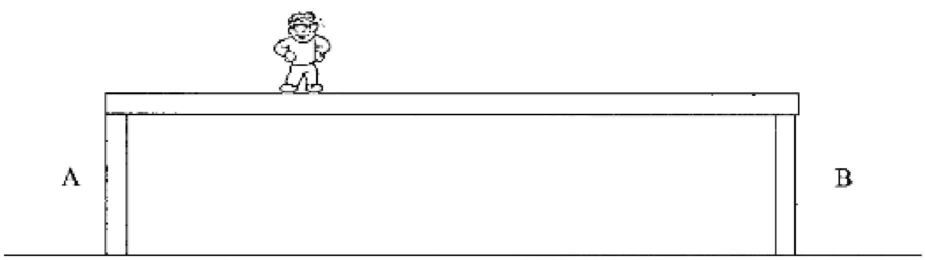
1. Consider a light string wound around a frictionless and massless wheel. The free end of the string is attached to a 1.2 kg mass that is allowed to fall freely. The wheel has a radius of 0.25 m. What torque is produced? (-2.94 Nm)



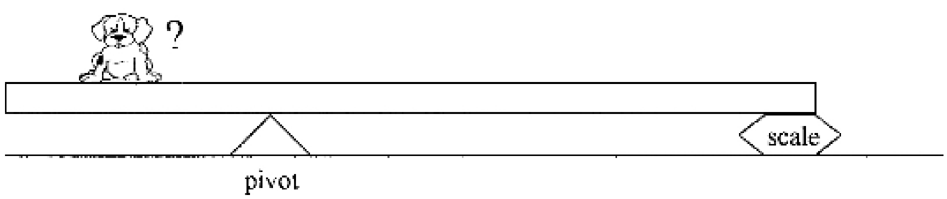
2. The magnitude of the maximum torque exerted by a person riding a bike when all his weight is put on the pedal is 92 Nm. What is the mass of the person if the pedals rotate in a circle of radius 17 cm? (55 kg)

3. A small boy of mass 30 kg is at one end of a seesaw of total length 3.0 m. Where must a girl of mass 21 kg sit in order that the seesaw be in equilibrium? (2.1 m from the pivot on the opposite as the boy)

4. Bob is standing on a bridge. The bridge itself weighs 10 000 N. The span between pillars A and B is 80 m. Bob is 20 m from the center of the bridge. Bob's mass is 100 kg. Assuming the bridge is in equilibrium, find the magnitude of the force exerted by pillar B on the bridge. (5.2×10^3 N)

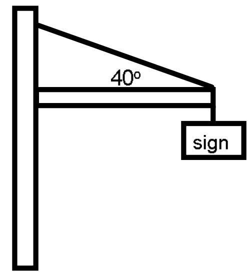


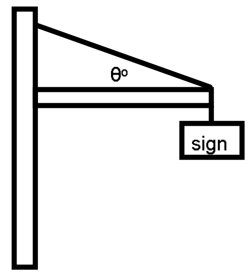
5. A 60 kg uniform board 2.4 m long is supported by a pivot 80 cm from the left end of the board and by a scale at the right end. Where should a 40 kg puppy be placed if the scale is to read 100 N? (61 cm from the left end of the board)



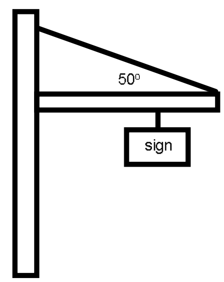
More Torque!

1. Determine the tension in the wire and the components of the force from the hinge. The beam has a mass of 170 kg, the sign has a mass of 75 kg, and the beam is 6.0 m long. (T = 2442 N, F_{hy} = 834 N, F_{hx} = 1870 N)



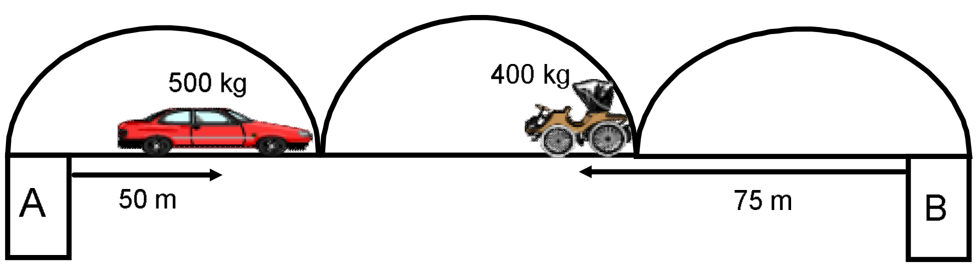


2. The cable in the diagram to the right will break if the tension reaches 1500 N. What is the smallest angle that can be made with the horizontal? The beam is 15 m long and has a weight of 1050 N. The sign has a weight of 500 N. (θ = 43°)

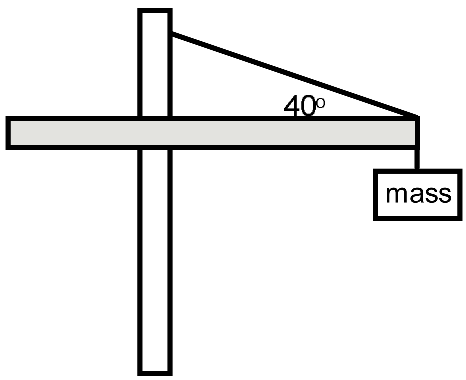


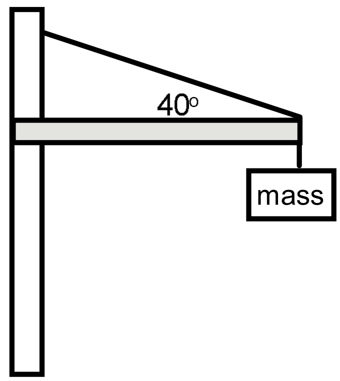
3. If the cable will break under a stress of 2300 N, what is the largest mass that can be hung from the beam? The beam is 150 kg and 8.0 m long. The cable makes an angle of 50° with the beam and the sign is 5.5 m from the left end of the beam. (152 kg)

4. The Morrissey bridge will collapse if column A must support more than 50000 N of weight. The bridge spans 225 m and has a mass of 8500 kg. Will the bridge collapse under the circumstances depicted in the diagram? (No, F_A = 46815 N)



A construction crane is designed such that part of the boom acts as a counterweight. The boom is constructed of uniform material with a linear density of 25 kg/m. The left side of the crane is 10 m long and the right side is 15 m.
a) If the mass at the right end is 300 kg what is the tension in the cable? (T = 6200 N)
b) What is the tension in the cable if there was no left side of the boom? (T = 7400 N)
c) Suppose each cable can support a tension of 12000 N. What is the maximum mass that each crane can support? (Left: 680 kg; Right: 600 kg)

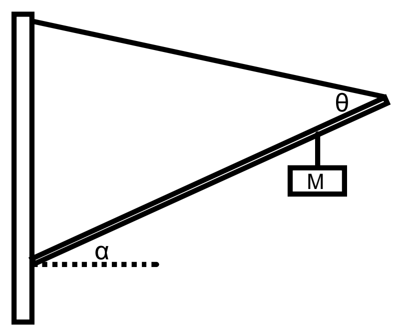




The cable in the diagram will break if the tension reaches 1800 N. The beam is 15 m long and has a mass of 60 kg and makes an angle of 30° with the horizontal. The cable makes an angle of 60° with the beam and the hanging mass is located 10 m from the hinge.

a) Calculate the maximum mass that can be attached. (271 kg)

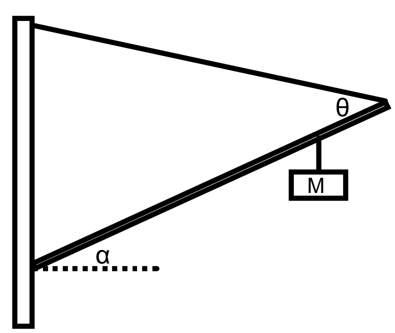
b) Calculate the net force on the hinge for that mass. (F_{net} = 2817 N 26° up from the beam)



The cable in the diagram will break if the tension reaches 2730 N. The beam is 12 m long and has a mass of 72 kg and makes an angle of 40° with the horizontal. The hanging mass is located 8.5 m from the hinge and has a mass of 144 kg.

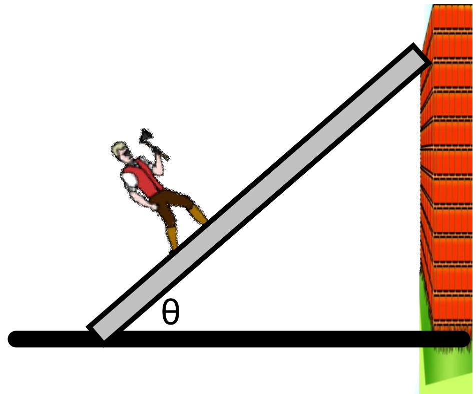
a) Calculate the minimum angle that can be used to attach to the beam. ($\theta = 22^{\circ}$)

b) Calculate the net force on the hinge for that angle. (Fnet = 3940 N 8.8° up from the beam)



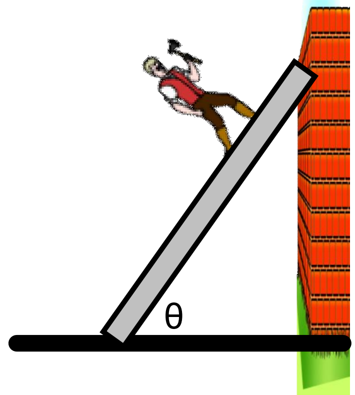
Calculate the coefficient of static friction necessary for the ladder to not slip.

- M_{ladder} = 25 kg
- M_{man} = 75 kg
- r_{ladder} = 5.0 m
- r_{man} = 1.5 m from base
- $\theta = 55^{o}$



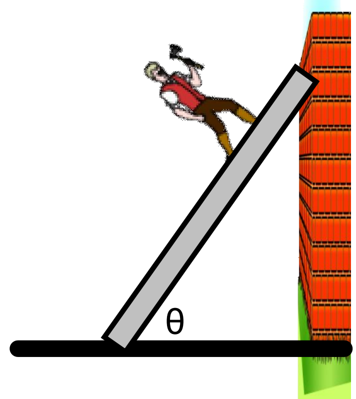
Calculate the coefficient of static friction necessary for the ladder to not slip.

- M_{ladder} = 55 kg
- Mman = 42 kg
- r_{ladder} = 7.0 m
- r_{man} = 5.5 m from base
- $\theta = 55^{o}$



Calculate the coefficient of static friction necessary for the ladder to not slip.

- M_{ladder} = 20 kg
- Mman = 64 kg
- r_{ladder} = 10 m
- r_{man} = 9.5 m from base
- $\theta = 65^{o}$



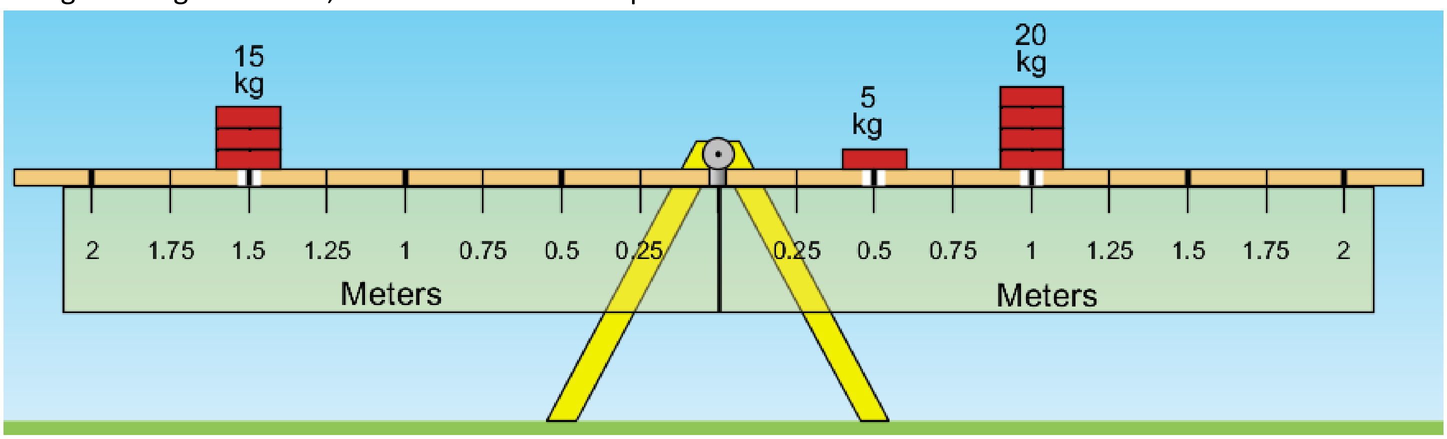
Torque & Static Equilibrium Concept Review

10.3 Section Review

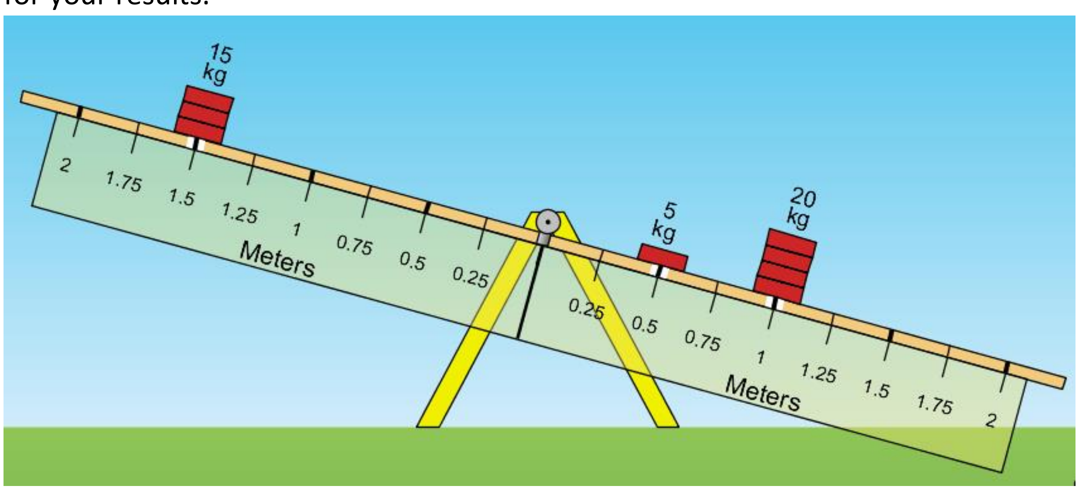
Chapter 10.3 pg. 502

1. **C** Explain how the vector sum of all of the forces acting on an object can be zero and yet the motion of the object can change.
2. **C** Describe the two different types of motion that can occur at the same time but you can analyze separately.
3. **MC** Describe three actions that you carry out every day that involve torque.
4. **K/U** How do you determine the sign (positive or negative) of torque?
5. **K/U** Define "lever arm."
6. **K/U** When is the unit "newton·metre" *not* equivalent to a joule?
7. **C** How can an object exert a torque on itself?
8. **K/U** What are the conditions for static equilibrium?

9. Using the diagram below, show that the net torque is zero.



10. Suppose the bricks are secured in place. Calculate the net torque when the beam is rotated clockwise 30°, shown in the image below. Did that just blow your mind? Will the beam move? Provide an explanation for your results.



11. Show, mathematically, that no matter what angle the beam is rotated it will remain in static equilibrium.
12. Is it possible for the net torque to be non-zero when horizontal but then become zero at some point as the beam rotates?

Centripetal Motion

1. An electric train moving at constant speed on a circular track of radius 1.0 m goes around the track every 10s. What is the centripetal acceleration of the train? (0.39 m/s^2)

2. A plane flying at a constant speed in a circular path of radius 5500 m completes one revolution every 485 s.
   a. What is the speed of the plane? (71.2 m/s)
   b. What is the acceleration of the plane? (0.922 m/s^2)

3. A stone attached to a string 2.0 m long is whirled in a horizontal circle. At what speed must the stone move for its centripetal acceleration to equal to the acceleration of gravity? (4.4 m/s)

4. The blade of a fan is 0.20 m long and makes 20 revolutions per second. What acceleration is experienced by a particle at the end of the blade? (3200 m/s^2)

5. An electron moves in a circular path of radius 0.20 m at a constant speed of 2.0×10^6 m/s.
   a. What is the period of its motion? (6.3×10^{-7} s)
   b. What is its centripetal acceleration? (2.0×10^{13} m/s^2)

6. An object moving along a circular path at a constant speed of 8.0 m/s completes one trip around the circle in 5.0 s.
   a. What is the radius of the circle? (6.4 m)
   b. What is the acceleration of the object? (10 m/s^2)

7. A student attaches a mass of 0.50 kg to one end of a rope. The student then swings the mass in a horizontal circle having a radius of 1.0 m so that the tangential speed is 4.0 m/s. What centripetal force must be exerted on the mass to keep it moving in a circle? (8.0 N)

8. A new communications satellite has a period of 5.6×10^3 s and an orbital radius of 6.8×10^6 m. If the mass is 2.0×10^3 kg, what is the centripetal force keeping it in orbit? (1.7×10^4 N)

9. If a 620 kg racecar takes 15.2 s to travel at constant speed once around a circular race track of 50.0 m radius, what are the centripetal acceleration of the car and centripetal force exerted by the track on the car's tires? (8.53 m/s^2; 5290 N)

10. A knight holds a 1.6 m chain attached to 10.0 kg mace. He whirls the mace in a circle. If the mace has a frequency of 0.20 Hz, what is the centripetal acceleration of the mace and the tension in the chain? (2.5 m/s^2; 25 N)

11. A 1.5 kg ball on a string is swung in a horizontal circle. The string will break under a tension of 350 N. Calculate the maximum velocity of the ball if the string is
    a. 0.50 m long. (10.8 m/s)
    b. 1.0 m long. (15.3 m/s)
    c. 1.5 m long. (18.7 m/s)
    d. Doubling the length increased the maximum speed by what factor?
    e. Tripling the length increased the maximum speed by what factor?
    f. How does the maximum speed vary with string length?

Banked and Unbanked Turns

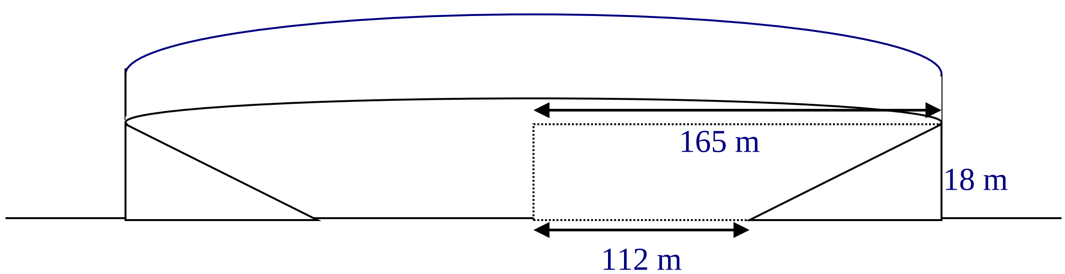
1. A car rounds an unbanked curve (radius = 92 m) without skidding at a speed of 26 m/s. What is the smallest possible coefficient of static friction between the tires and the road? (0.75)

2. At what angle should a curve of radius 150 m be banked so cars can travel safely at 25 m/s without relying on friction? (23^o)

3. A curve of radius 120 m is banked at an angle of 18^o. At what speed can it be negotiated under icy conditions when friction is neglected? (20 m/s)

4. A car is safely negotiating an unbanked circular turn at a speed of 21 m/s. The maximum static frictional force acts on the tires. Suddenly, a wet patch in the road reduces the maximum static frictional force a factor of three. If the car is to continue safely around the curve, to what speed must the driver slow the car? (12 m/s)

5. On a banked race track, the smallest circular path on which cars can move has a radius of 112 m, while the largest has a radius of 165 m, as the drawing illustrates. The height of the outer wall is 18 m. Find the smallest and largest speed at which cars can move on this track without relying on friction. (19 m/s, 23 m/s)



6. Two curves on a highway have the same radii. However, one is unbanked and the other is banked at an angle θ. A car can safely travel along the unbanked curve at a maximum speed v_o under conditions when the coefficient of static friction between the tires and the road is 0.81. The banked curve is frictionless, and the car can negotiate it at the same maximum speed v_o. Find the angle θ of the banked curve. (39^o)

Circular Motion Review

11.2 Section Review

Ch. 11 pg. 657

1. K/U Define uniform circular motion and describe the type of acceleration that is associated with it.

2. K/U Study the diagram in Figure 11.6 on page 552. Explain what approximation was made in the derivation that requires you to imagine what occurs as the angle becomes smaller and smaller.

3. C What are the benefits of using the concept of centripetal acceleration rather than working on a traditional Cartesian coordinate system?

4. K/U Explain how centripetal force differs from common forces, such as the forces of friction and gravity.

5. K/U If you were swinging a ball on a string around in a circle in a vertical plane, at what point in the path would the string be the most likely to break? Explain why. In what direction would the ball fly when the string broke?

6. C Explain why gravity does *not* affect circular motion in a horizontal plane, and why it *does* affect a similar motion in a vertical plane.

7. C Describe three examples in which different forces are contributing the centripetal force that is causing an object to follow a circular path.

8. MC When airplane pilots make very sharp turns, they are subjected to very large *g* forces. Based on your knowledge of centripetal force, explain why this occurs.

9. C A centrifugal force, if it existed, would be directed radially outward from the centre of a circle during circular motion. Explain why it feels as though you are being thrown outward when you are riding on an amusement park ride that causes you to spin in a circle.

10. K/U On a highway, why are sharp turns banked more steeply than gentle turns? Use vector diagrams to clarify your answer.

11. I Imagine that you are in a car on a major highway. When going around a curve, the car starts to slide sideways down the banking of the curve. Describe conditions that could cause this to happen.

UNIT PROJECT PREP

Parts of your catapult launch mechanism will move in part of a circle. The payload, once launched, will be a projectile.

- How will your launch mechanism apply enough centripetal force to the payload to move it in a circle, while still allowing the payload to be released?
- How will you ensure that the payload is launched at the optimum angle for maximum range?
- What data will you need to gather from a launch to produce the most complete possible analysis of the payload's actual path and flight parameters?

Circular Motion Review

PRACTICE PROBLEMS — Ch. 11 pg. 559

15. A boy is twirling a 155 g ball on a 1.65 m string in a horizontal circle. The string will break if the tension reaches 208 N. What is the maximum speed at which the ball can move without breaking the string?

16. An electron (mass 9.11×10^{-31} kg) orbits a hydrogen nucleus at a radius of 5.3×10^{-11} m at a speed of 2.2×10^{6} m/s. Find the centripetal force acting on the electron. What type of force supplies the centripetal force?

17. A stone of mass 284 g is twirled at a constant speed of 12.4 m/s in a vertical circle of radius 0.850 m. Find the tension in the string **(a)** at the top and **(b)** at the bottom of the revolution. **(c)** What is the maximum speed the stone can have if the string will break when the tension reaches 33.7 N?

18. You are driving a 1654 kg car on a level road surface and start to round a curve at 77 km/h. If the radius of curvature is 129 m, what must be the frictional force between the tires and the road so that you can safely make the turn?

19. A stunt driver for a movie needs to make a 2545 kg car begin to skid on a large, flat, parking lot surface. The force of friction between his tires and the concrete surface is 1.75×10^{4} N and he is driving at a speed of 24 m/s. As he turns more and more sharply, what radius of curvature will he reach when the car just begins to skid?

PRACTICE PROBLEMS — Ch. 11 pg. 566

20. An engineer designed a turn on a road so that a 1225 kg car would need 4825 N of centripetal force when travelling around the curve at 72.5 km/h. What is the radius of curvature of the road?

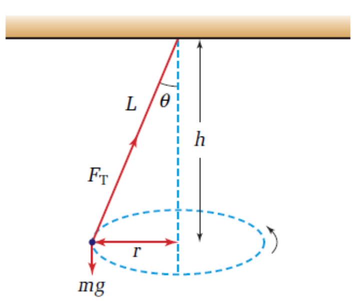
21. A car exits a highway on a ramp that is banked at 15° to the horizontal. The exit ramp has a radius of curvature of 65 m. If the conditions are extremely icy and the driver cannot depend on any friction to help make the turn, at what speed should the driver travel so that the car will not skid off the ramp?

22. An icy curve with a radius of curvature of 175 m is banked at 12°. At what speed must a car travel to ensure that it does not leave the road?

23. An engineer must design a highway curve with a radius of curvature of 155 m that can accommodate cars travelling at 85 km/h. At what angle should the curve be banked?

Conceptual Problem

- A conical pendulum swings in a circle, as shown in the diagram. Show that the form of the equation relating the angle that the string of the pendulum makes with the vertical to the speed of the pendulum bob is identical to the equation for the banking of curves. The pendulum has a length L, an angle θ with the vertical, a force of tension F_T in the string, a weight mg, and swings in a circular path of radius r. The plane of the circle is a distance h from the ceiling from which the pendulum hangs.



Ch. 11 Problems for Understanding pg. 570.

Circular Motion Review

21. A ball moving in a circular path with a constant speed of 3.0 m/s changes direction by 40.0° in 1.75 s.
(a) What is its change in velocity?
(b) What is the acceleration during this time?

22. A beam of electrons is caused to move in a circular path of radius 3.00 m at a velocity of 2.00×10^7 m/s. The electron mass is 9.11×10^{-31} kg.
(a) What is the centripetal acceleration of one of the electrons?
(b) What is the centripetal force on one electron?

23. A car travelling on a curved road will skid if the road does not supply enough friction. Calculate the centripetal force required to keep a 1500 kg car travelling at 65 km/h on a flat curve of radius 1.0×10^2 m. What must be the coefficient of friction between the car's wheels and the ground?

24. Consider an icy curved road, banked 6.2° to the horizontal, with a radius of curvature of 75.0 m. At what speed must a 1200 kg car travel to stay on the road?

25. You want to design a curve, with a radius of curvature of 350 m, so that a car can turn at a velocity of 15 m/s on it without depending on friction. At what angle must the road be banked?

26. A motorcycle stunt rider wants to do a loop-the-loop within a vertical circular track. If the radius of the circular track is 10.0 m, what minimum speed must the motorcyclist maintain to stay on the track?

27. An amusement park ride consists of a large cylinder that rotates around a vertical axis. People stand on a ledge inside. When the rotational speed is high enough, the ledge drops away and people "stick" to the wall. If the period of rotation is 2.5 s and the radius is 2.5 m, what is the minimum coefficient of friction required to keep the riders from sliding down?

28. Use your understanding of the physics of circular motion to explain why we are not thrown off Earth like heavy particles in a centrifuge or mud off a tire, even though Earth is spinning at an incredible rate of speed. To make some relevant calculations, assume that you are standing in the central square of Quito, a city in Ecuador that is located on Earth's equator.
(a) Calculate your average speed around the centre of Earth.
(b) Determine the centripetal force needed to move you in a circle with Earth's radius at the speed that you calculated in part (a).
(c) In what direction does the centripetal force act? What actual force is providing the amount of centripetal force that is required to keep you in uniform circular motion on Earth's surface?
(d) What is your weight?
(e) What is the normal force exerted on you by Earth's surface?
(f) Use the calculations just made and other concepts about circular motion that you have been studying to explain why you are not thrown off Earth as it spins around its axis.

Additional Concept Questions

1. Suppose a coin is on the edge of a rotating disc (see image below). With careful timing you flick the coin perfectly so all the force is directed towards the centre. Describe the path of the coin relative to the straight-line distance to the centre of the disc.

Circular Motion Review

2. Two people are standing on a large merry-go-round, one person near the centre and the other on the edge and the face each other.
    a. Describe, in general, how the speeds of each person compare.
    b. The person on the edge throws a ball straight towards the person in the centre. Relative to the thrower, will the ball go directly to the other person, miss to the left or miss to the right? Support your answer with an explanation.
    c. Same situation and question as (b) but now the person at the centre throws the ball straight at the other.

Universal Gravitation

PRACTICE PROBLEMS

Ch. 12 pg. 580.

1. Find the gravitational force between Earth and the Sun. (See Appendix B, Physical Constants and Data.)
2. Find the gravitational force between Earth and the Moon. (See Appendix B, Physical Constants and Data.)
3. How far apart would you have to place two 7.0 kg bowling balls so that the force of gravity between them would be 1.25×10^{-4} N? Would it be possible to place them at this distance? Why or why not?
4. Find the gravitational force between the electron and the proton in a hydrogen atom if they are 5.30×10^{-11} m apart. (See Appendix B, Physical Constants and Data.)
5. On Venus, a person with mass 68 kg would weigh 572 N. Find the mass of Venus from this data, given that the planet's radius is 6.31×10^{6} m.
6. In an experiment, an 8.0 kg lead sphere is brought close to a 1.5 kg mass. The gravitational force between the two objects is 1.28×10^{-8} N. How far apart are the centres of the objects?
7. The radius of the planet Uranus is 4.3 times the radius of earth. The mass of Uranus is 14.7 times Earth's mass. How does the gravitational force on Uranus' surface compare to that on Earth's surface?
8. Along a line connecting Earth and the Moon, at what distance from Earth's centre would an object have to be located so that the gravitational attractive force of Earth on the object was equal in magnitude and opposite in direction from the gravitational attractive force of the Moon on the object?

PRACTICE PROBLEMS

Ch. 12 pg. 586

9. Jupiter's moon Io orbits Jupiter once every 1.769 days. Its average orbital radius is 4.216×10^{8} m. What is Jupiter's mass?
10. Charon, the only known moon of the planet Pluto, has an orbital period of 6.387 days at an average distance of 1.9640×10^{7} m from Pluto. Use Newton's form of Kepler's third law to find the mass of Pluto from this data.
11. Some weather satellites orbit Earth every 90.0 min. How far above Earth's surface is their orbit? (Hint: Remember that the centre of the orbit is the centre of Earth.)
12. How fast is the moon moving as it orbits Earth at a distance of 3.84×10^{5} km?
13. On each of the *Apollo* lunar missions, the command module was placed in a very low, approximately circular orbit above the Moon. Assume that the average height was 60.0 km above the surface and that the Moon's radius is 7738 km.
    (a) What was the command module's orbital period?
    (b) How fast was the command module moving in its orbit?
14. A star at the edge of the Andromeda galaxy appears to be orbiting the centre of that galaxy at a speed of about 2.0×10^{2} km/s. The star is about 5×10^{9} AU from the centre of the galaxy. Calculate a rough estimate of the mass of the Andromeda galaxy. Earth's orbital radius (1 AU) is 1.49×10^{8} km.

Universal Gravitation

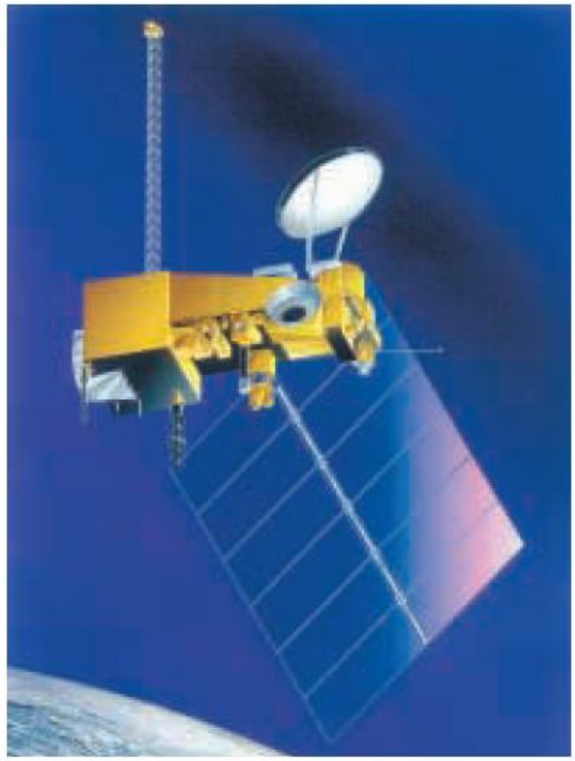
PRACTICE PROBLEMS

Ch. 12 pg. 591

15. The polar-orbiting environmental satellites (POES) and some military satellites orbit at a much lower level in order to obtain more detailed information. POES complete an Earth orbit 14.1 times per day. What are the orbital speed and the altitude of POES?

16. The International Space Station orbits at an altitude of approximately 226 km. What is its orbital speed and period?

17. (a) The planet Neptune has an orbital radius around the Sun of about 4.50×10^{12} m. What are its period and its orbital speed?
    (b) Neptune was discovered in 1846. How many orbits has it completed since its discovery?



NASA operates two polar-orbiting environmental satellites (POES) designed to collect global data on cloud cover; surface conditions such as ice, snow, and vegetation; atmospheric temperatures; and moisture, aerosol, and ozone distributions.

Problems for Understanding

Ch. 12 pg. 597.

22. The gravitational force between two objects is 80.0 N. What would the force become if the mass of one object was halved and the distance between the two objects was doubled?

23. Two stars of masses $m*$ and $3m*$ are 7.5×10^{11} m apart. If the force on the large star is F, which of the following is the force on the small star?
    (a) $F/9$ (b) $F/3$ (c) F (d) $3F$ (e) $9F$

24. For the above situation, if the acceleration of the small star is a, what is the acceleration of the large star?
    (a) $a/9$ (b) $a/3$ (c) a (d) $3a$ (e) $9a$

25. (a) Use Newton's law of universal gravitation and the centripetal force of the Sun to determine Earth's orbital speed. Assume that Earth orbits in a circle.
    (b) What is Earth's centripetal acceleration around the Sun?

26. Calculate the Sun's acceleration caused by the force of Earth.

27. A space shuttle is orbiting Earth at an altitude of 295 km. Calculate its acceleration and compare it to the acceleration at Earth's surface.

28. Orbital motions are routinely used by astronomers to calculate masses. A ring of high-velocity gas, orbiting at approximately 3.4×10^4 m/s at a distance of 25 light-years from the centre of the Milky Way, is considered to be evidence for a black hole at the centre. Calculate the mass of this putative black hole. How many times greater than the Sun's mass is it?

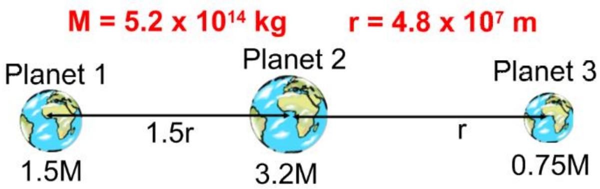
29. In a Cavendish experiment, two 1.0 kg spheres are placed 50.0 cm apart. Using the known value of G, calculate the gravitational force between these spheres. Compare this force to the weight of a flea.

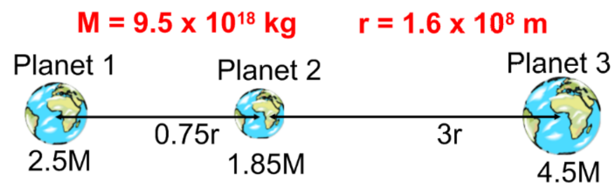
30. The Hubble space telescope orbits Earth with an orbital speed of 7.6×10^3 m/s.
    (a) Calculate its altitude above Earth's surface.
    (b) What is its period?

31. The Moon orbits Earth at a distance of 3.84×10^8 m. What are its orbital velocity and period?

Universal Gravitation

1. Calculate the net force on each planet in the images below.



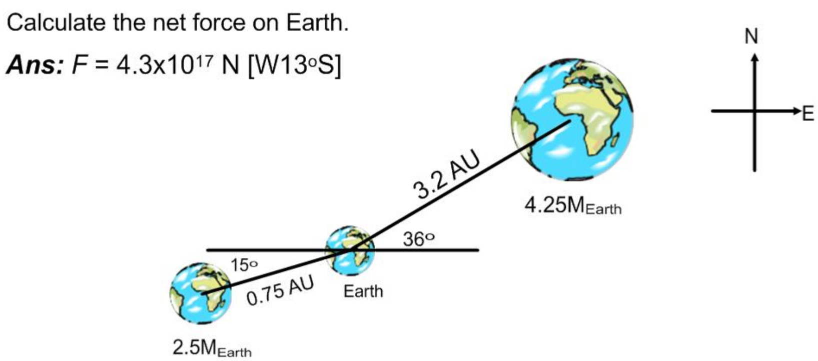


12.2 Section Review

1. (C) Explain Newton's thought experiment about "launching a cannon-ball satellite."
2. (I) Why must a geostationary satellite orbit over the equator? To answer that question, think about the point that is the centre of the orbit. If you launched a satellite that had a period of 24 hr, but it did not start out over the equator, what path would it follow? If you were at the spot on Earth just below the point where the satellite started to orbit, how would the path of the satellite appear to you?
3. (K/U) What conditions create apparent weightlessness when an astronaut is in an orbiting spacecraft?
4. (K/U) How could you discover a planet without seeing it with a telescope?

1. Suppose you launch a projectile at an angle at Earth's surface. Then you launch the same projectile on a flat part on the surface of Mars. Compare and contrast the trajectory properties of each projectile (neglect all air resistance).

2. Use the information in the image below.



3. Calculate how far above the Earth's surface you have to be to experience 0.5g? (2.64×10^6 m)

4. Calculate the radius of a planet that has the same surface gravity but is 2.5 times as massive as the Earth.

5. Two planets are separated by 8.5×10^8 m. One planet is 12 times as massive as the other. Calculate where an object would have to be position to experience the same magnitude of force from each planet.

6. Two planets are separated by 2.5×10^8 m. One planet is 8 times as massive as the other. Calculate where an object would have to be position to experience a force of gravity from the larger planet that is twice the smaller.

7. Calculate the force of gravity between the Earth and Sun and then between the Earth and Moon.
   a. Which object is responsible for ocean tides on Earth?
   b. A tidal force is a measure of the change in force with distance. Calculate the magnitude in the tidal force for the Earth-Sun and Earth-Moon systems by first using your calculus differentiation rules to obtain a formula.
   c. Now provide an explanation to your answer for (a).
8. Calculate:
   a. The altitude of a satellite that is in geosynchronous orbit.
   b. The orbital velocity of such a satellite.

Physics 122

Charge and Coulomb's Law (Two Charges)

1. How many electrons are needed to make up 25 C of charge?
   (1.6×10^{20} electrons)

2. How many coulombs of charge do 1.88×10^{19} electrons have?
   (3.01 C)

3. How many electrons must be removed from a small pith ball to give it a charge of 1.0×10^{-12} C? (6.3×10^{6})

4. How many excess electrons are on a ball with a charge of 2.04×10^{-17} C?
   (128)

5. Two charges, q_1 and q_2, are separated by a distance, d, and exert a force, F, on each other. What new force will exist if:
   a) q_2 is doubled?
   b) d is tripled?
   c) q_1 is halved and q_2 is tripled?
   d) q_2 is doubled and d is tripled?
   e) q_1 is halved, q_2 is one-fourth its original value and d is one-fourth its original value?

6. A positive charge of 1.8×10^{-6} C and a negative charge of 1.0×10^{-6} C are 0.040 m apart. What is the magnitude of the force between the two charges?
   (10 N).

7. A negative charge of 4.0×10^{-6} C exerts a force of repulsion of 7.2 N on a second charge. The charges are separated by 0.050 m. What is the sign and magnitude of the second charge? (-5.0×10^{-7} C)

8. How far apart are two charges of 1.0 μ C and –1.0 μC if they exert a force of attraction of 440 N on each other? (4.5×10^{-3} m)

9. What is the magnitude of the electrostatic force exerted by the proton in a hydrogen atom on the electron that orbits the nucleus when the electron is
   5.3×10^{-11} m from the proton? (8.2×10^{-8} N)

10. How far apart are two electrons if they exert a force of repulsion of 1.80×10^{-10} N on each other? (1.13×10^{-9} m)

11. At what separation distance do two point charges of 2.0 μC and –3.0 μC exert a force of attraction on each other of 565 N? (9.8×10^{-3} m)

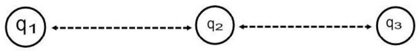
12. A distance of 0.64 m separates two neutral spheres. If 2.0×10^{13} electrons are removed from one sphere and placed on the other, what is the magnitude of the force that exists between the spheres? (0.23 N)

13. Two spheres, one with three times the charge of the other, are located 24 cm apart and exert a repulsive force of 72 N on each other. What is the magnitude of the charge of the sphere with more charge? (3.7×10^{-5} C)

Science 122

Electrostatics: 3 Charges

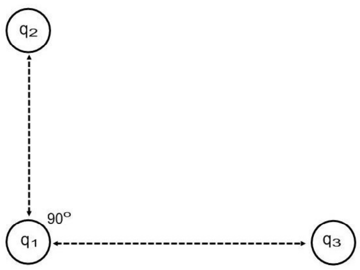
1. Three charges are lined up (see image below). Given the information that follows, what is the net electrostatic force acting on q_1? $q_1 = 3.5\,\mu\text{C}$, $q_2 = -1.5\mu C$, $q_3 = 4.0\,\mu\text{C}$, $r_{12} = 0.54\,\text{m}$, $r_{23} = 1.39\,\text{m}$



2. Three charges are lined up (see image below). Given the information that follows, what is the net electrostatic force acting on q_2? $q_1 = 3.5\,\mu\text{C}$, $q_2 = -1.5\mu C$, $q_3 = 4.0\,\mu\text{C}$, $r_{12} = 0.54\,\text{m}$, $r_{23} = 1.39\,\text{m}$

3. Three charges are lined up (see image below). Given the information that follows, what is the net electrostatic force acting on q_3? $q_1 = 3.5\,\mu\text{C}$, $q_2 = -1.5\ \mu\text{C}$, $q_3 = 4.0\,\mu\text{C}$, $r_{12} = 0.54\,\text{m}$, $r_{23} = 1.39\,\text{m}$

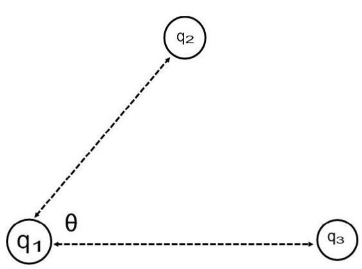
4. Three charges are arranged as depicted below. Given the information that follows, what is the net electrostatic force acting on q_1? $q_1 = -2.5\,\mu\text{C}$, $q_2 = -3.1\,\mu\text{C}$, $q_3 = -3.8\,\mu\text{C}$, $r_{12} = 0.25\,\text{m}$, $r_{13} = 0.75\,\text{m}$



5. Three charges are arranged as depicted below. Given the information that follows, what is the net electrostatic force acting on q_2? $q_1 = -2.5\,\mu\text{C}$, $q_2 = -3.1\,\mu\text{C}$, $q_3 = -3.8\,\mu\text{C}$, $r_{12} = 0.25\,\text{m}$, $r_{13} = 0.75\,\text{m}$

6. Three charges are arranged as depicted below. Given the information that follows, what is the net electrostatic force acting on q_3? $q_1 = -2.5\,\mu\text{C}$, $q_2 = -3.1\,\mu\text{C}$, $q_3 = -3.8\,\mu\text{C}$, $r_{12} = 0.25\,\text{m}$, $r_{13} = 0.75\,\text{m}$

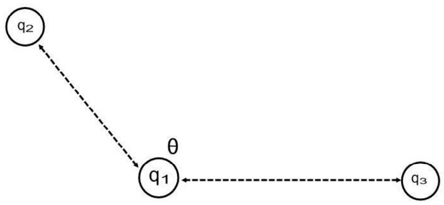
7. Three charges are arranged as depicted below. Given the information that follows, what is the net electrostatic force acting on q_1? $q_1 = -7.25\,\mu\text{C}$, $q_2 = -5.0\,\mu\text{C}$, $q_3 = 9.5\,\mu\text{C}$, $r_{12} = 1.75\,\text{m}$, $r_{13} = 2.7\,\text{m}$, $\theta = 25^\circ$



8. Three charges are arranged as depicted below. Given the information that follows, what is the net electrostatic force acting on q_2? $q_1 = -7.25\,\mu\text{C}$, $q_2 = -5.0\,\mu\text{C}$, $q_3 = 9.5\,\mu\text{C}$, $r_{12} = 1.75\,\text{m}$, $r_{13} = 2.7\,\text{m}$, $\theta = 25^\circ$

9. Three charges are arranged as depicted below. Given the information that follows, what is the net electrostatic force acting on q_3? $q_1 = -7.25\,\mu\text{C}$, $q_2 = -5.0\,\mu\text{C}$, $q_3 = 9.5\,\mu\text{C}$, $r_{12} = 1.75\,\text{m}$, $r_{13} = 2.7\,\text{m}$, $\theta = 25^\circ$

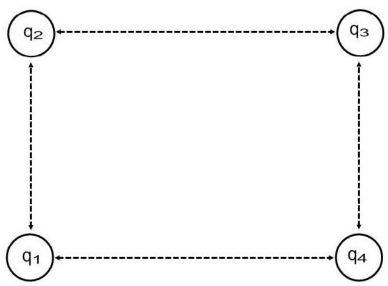
10. Three charges are arranged as depicted below. Given the information that follows, what is the net electrostatic force acting on q_1? $q_1 = 10.0\,\mu\text{C}$, $q_2 = -5.0\,\mu\text{C}$, $q_3 = -20.0\,\mu\text{C}$, $r_{12} = 1.5\,\text{m}$, $r_{13} = 3.0\,\text{m}$, $\theta = 150^\circ$



11. Three charges are arranged as depicted below. Given the information that follows, what is the net electrostatic force acting on q_2? $q_1 = 10.0\,\mu\text{C}$, $q_2 = -5.0\,\mu\text{C}$, $q_3 = -20.0\,\mu\text{C}$, $r_{12} = 1.5\,\text{m}$, $r_{13} = 3.0\,\text{m}$, $\theta = 150^\circ$

12. Three charges are arranged as depicted below. Given the information that follows, what is the net electrostatic force acting on q_3? $q_1 = 10.0\,\mu\text{C}$, $q_2 = -5.0\,\mu\text{C}$, $q_3 = -20.0\,\mu\text{C}$, $r_{12} = 1.5\,\text{m}$, $r_{13} = 3.0\,\text{m}$, $\theta = 150^\circ$

13. Four charges are arranged in a rectangle (depicted below). Given the information that follows, what is the net electrostatic force acting on q_1? $q_1 = 5.0\,\mu\text{C}$, $q_2 = -7.0\,\mu\text{C}$, $q_3 = -3.0\,\mu\text{C}$, $q_4 = 9.0\,\mu\text{C}$, $r_{12} = 3.0\,\text{m}$, $r_{13} = 4.0\,\text{m}$



14. Four charges are arranged in a rectangle (depicted below). Given the information that follows, what is the net electrostatic force acting on q_2? $q_1 = 5.0\,\mu\text{C}$, $q_2 = -7.0\,\mu\text{C}$, $q_3 = -3.0\,\mu\text{C}$, $q_4 = 9.0\,\mu\text{C}$, $r_{12} = 3.0\,\text{m}$, $r_{13} = 4.0\,\text{m}$

15. Four charges are arranged in a rectangle (depicted below). Given the information that follows, what is the net electrostatic force acting on q_3? $q_1 = 5.0\,\mu\text{C}$, $q_2 = -7.0\,\mu\text{C}$, $q_3 = -3.0\,\mu\text{C}$, $q_4 = 9.0\,\mu\text{C}$, $r_{12} = 3.0\,\text{m}$, $r_{13} = 4.0\,\text{m}$

16. Four charges are arranged in a rectangle (depicted below). Given the information that follows, what is the net electrostatic force acting on q_4? $q_1 = 5.0\,\mu\text{C}$, $q_2 = -7.0\,\mu\text{C}$, $q_3 = -3.0\,\mu\text{C}$, $q_4 = 9.0\,\mu\text{C}$, $r_{12} = 3.0\,\text{m}$, $r_{13} = 4.0\,\text{m}$

PRACTICE PROBLEMS MHR Pg. 692

1. What is the potential difference of a battery if it does 7.50×10^{-2} J of work when it moves 3.75×10^{-3} C of charge onto the anode?

2. A 9.00 V battery causes a charge of 4.20×10^{-2} C to move through a circuit. Calculate the work done on the charge.

3. A 12 V battery does 0.75 J of work on a quantity of charge it moved through a circuit. Calculate the amount of charge that was moved.

PRACTICE PROBLEMS MHR Pg. 696

4. A battery sends a 2.25 A current through a circuit for 1.50 min. If a total of 8.10×10^{2} J of work was done by the current, what was the potential difference of the battery?

5. How long would it take a 17 V battery, sending a 5.0 A current through a circuit, to do 680 J of work?

6. How much work is done by a 25.0 V battery when it drives a 4.70 A current through a circuit for 36.0 s?

7. If a 160 V battery did 9.6×10^{5} J of work in 2 min, what was the current?

8. A light draws a current of 0.48 A. How long must it be left on for charge of 36 C to pass through it?

9. An electric circuit draws 20 A. If the electric potential drop over the entire circuit is 120 V, calculate the total charge passing through the circuit in 1 h.

10. A cellular phone battery is recharged in 0.25 h after receiving 2.5×10^{3} C of charge. Calculate the amount of electric current that the battery draws during recharging?

11. A physics student wishes to determine the amount of electric energy consumed in one day at his school as a result of classroom and hallway lighting. A quick survey revealed that there were approximately 200 40W fluorescent lights operating under a potential difference of 240 V for 16 hours each day. How much electric energy was used to light the school for one day?

PRACTICE PROBLEMS MHR Pg. 700

12. Calculate the current if 2.85×10^{20} elementary charges pass a point in a circuit in 5.70 min.

13. A 16.0 V battery does 5.40×10^{4} J of work in 360.0 s.
    (a) Calculate the current through the battery.
    (b) Calculate the number of elementary charges that pass through the battery.

14. Calculate the number of elementary charges that pass a point in a circuit when a current of 3.50 A flows for 24.0 s.

15. In transferring 2.5×10^{20} elementary charges in 12 s, a battery does 68 J of work.
    (a) Calculate the current through the battery.
    (b) Calculate the potential difference of the battery.

PRACTICE PROBLEMS MHR Pg. 714

21. The heating element of an electric kettle draws 7.5 A when connected to a 120 V power supply. What is the resistance of the element?

22. A toaster is designed to operate on a 120 V (1.20×10^2 V) system. If the resistance of the toaster element is 9.60 Ω, what current does it draw?

23. A small, decorative light bulb has a resistance of 36 Ω. If the bulb draws 140 mA, what is its operating potential difference? (**Note:** The prefix "m" before a unit always means "milli-" or one one-thousandth. 1 mA is 1×10^{-3} A.)

24. The light bulb in the tail-light of an automobile with a 12 V electrical system has a resistance of 5.8 Ω. The bulb is left on for 8.0 min.

(a) What quantity of charge passes through the bulb?

(b) What was the current in the tail-light?

25. An iron transforms 3.35×10^5 J of electric energy to thermal energy in the 4.50 min it takes to press a pair of slacks. If the iron operates at 120 V (1.20×10^2 V), what is its resistance?

26. In Europe, some countries use 240 V (2.40×10^2 V) power supplies. How long will it take an electric kettle that has a resistance of 60.0 Ω to produce 4.32×10^5 J of thermal energy?

PRACTICE PROBLEMS MHR Pg. 719

27. Three loads, connected in series to a battery, have resistances of 15.0 Ω, 24.0 Ω, and 36.0 Ω. If the current through the first load is 2.2A, calculate

(a) the potential difference across each of the loads

(b) the equivalent resistance for the three loads

(c) the potential difference of the battery

28. Two loads, 25.0 Ω and 35.0 Ω, are connected in series. If the potential difference across the 25.0 Ω load is 65.0 V, calculate

(a) the potential difference across the 35.0 Ω load

(b) the potential difference of the battery

29. Two loads in series are connected to a 75.0 V battery. One of the loads is known to have a resistance of 48.0 Ω. You measure the potential difference across the 48.0 Ω load and find it is 40.0 V. Calculate the resistance of the second load.

30. Two loads, R_1 and R_2, are connected in series to a battery. The potential difference across R_1 is 56.0 V. The current measured at R_2 is 7.00 A. If R_2 is known to be 24.0 Ω, find

(a) the resistance of R_1

(b) the potential difference of the battery

(c) the equivalent resistance of the circuit

31. A 240 V (2.40×10^2 V) power supply is connected to three loads in series. The current in the circuit is measured to be 1.50 A. The resistance of the first load is 42.0 Ω and the potential difference across the second load is 111 V. Calculate the resistance of the third load.

PRACTICE PROBLEMS MHR Pg. 724

Draw a circuit diagram for each problem below. As an aid, write the known values on the diagram.

32. A 9.00 V battery is supplying power to three light bulbs connected in parallel to each other. The resistances, R_1, R_2, and R_3, of the bulbs are 13.5 Ω, 9.00 Ω, and 6.75 Ω, respectively. Find the current through each load and the equivalent resistance of the circuit.

33. A light bulb and a heating coil are connected in parallel to a 45.0 V battery. The current from the battery is 9.75 A, of which 7.50 A passes through the heating coil. Find the resistances of the light bulb and the heating coil, and the equivalent resistance for the circuit.

34. A circuit contains a 12.0 Ω load in parallel with an unknown load. The current in the 12.0 Ω load is 3.20 A, while the current in the unknown load is 4.80 A. Find the resistance of the unknown load and the equivalent resistance for the two parallel loads.

35. A current of 4.80 A leaves a battery and separates into three currents running through three parallel loads. The current to the first load is 2.50 A, the current through the second load is 1.80 A, and the resistance of the third load is 108 Ω. Calculate (a) the equivalent resistance for the circuit, and (b) the resistance of the first and second loads.

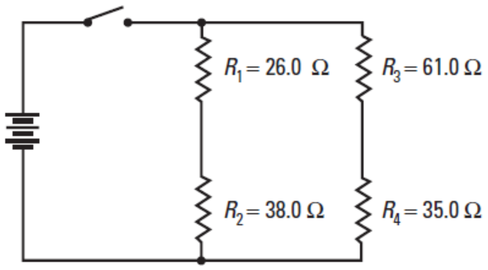
PRACTICE PROBLEMS MHR Pg. 728

36. For the circuit in the diagram shown below, the potential difference of the power supply is 144 V. Calculate

(a) the equivalent resistance for the circuit

(b) the current through R_1

(c) the potential difference across R_3

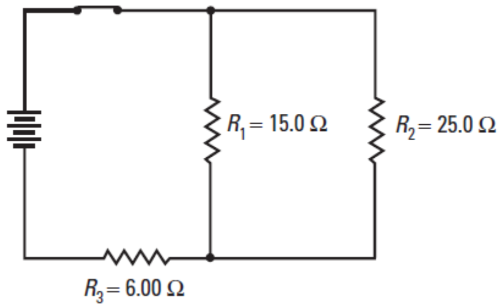


37. For the circuit shown in the diagram below, the potential difference of the power supply is 25.0 V. Calculate

(a) the equivalent resistance of the circuit

(b) the potential difference across R_3

(c) the current through R_1



PRACTICE PROBLEMS MHR Pg. 731

38. A battery has an *emf* of 15.0 V and an internal resistance of 0.0800 Ω.

(a) What is the terminal voltage if the current to the circuit is 2.50 A?

(b) What is the terminal voltage when the current increases to 5.00 A?

39. A battery has an internal resistance of 0.120 Ω. The terminal voltage of the battery is 10.6 V when a current of 7.00 A flows from it.

(a) What is its *emf*?

(b) What would be the potential difference of its terminals if the current was 2.20 A?

PRACTICE PROBLEMS MHR Pg. 737

40. An electric toaster is rated at 875 W at 120 V.

(a) Calculate the current the toaster draws when it is on.

(b) Calculate the electric resistance of the toaster.

41. A light bulb designed for use with a 120 V power supply has a filament with a resistance of 240 Ω.

(a) What is the power output of the bulb when the potential difference is 120 V?

(b) If the bulb is inadvertently connected to an 80.0 V power supply, what would be the power output of the bulb?

(c) If you wanted to construct a bulb to use with an 80.0 V power supply so that it would have the same power output as a 240 Ω bulb connected to a 120 V power supply, what should be the resistance of the bulb's filament?

42. A heater has a resistance of 15 Ω.

(a) If the heater is drawing a current of 7.5 A, what is its power output?

(b) If the current to the heater was cut in half, what would happen to the power output?

PRACTICE PROBLEMS MHR Pg. 740

43. (a) What is the power output of a 45 Ω resistance when connected to

- a 180 V power supply?
- a 270 V power supply?

(b) Find the ratio of the potential differences and the ratio of the power outputs. What is the relationship between the two ratios?

44. A load has a power rating of 160 W when the current in it is 6.0 A. What will be the power output if the current increases to 15 A?

45. (a) What is the power output of a circuit that consists of a 25 Ω resistance when connected to a 100 V supply?

(b) If a second 25 Ω resistance is connected in series with the first, what will be the power output of the circuit? Why has the power output of the circuit decreased?

PRACTICE PROBLEMS MHR Pg. 744

46. A filament in a light bulb rated at 192 W, has a resistance of 12.0 Ω. Calculate the potential difference at which the bulb is designed to operate.

47. An electric kettle is rated at 960 W when operating at 120 V. What must be the resistance of the heating element in the kettle?

48. If a current of 3.50 A is flowing through a resistance of 24.0 Ω, what is the power output?

49. A toaster that has a power rating of 900 W (9.00×10^2 W) draws a current of 7.50 A. If 2.40×10^5 J of electric energy are consumed while toasting some bread, calculate how much charge passed through the toaster.

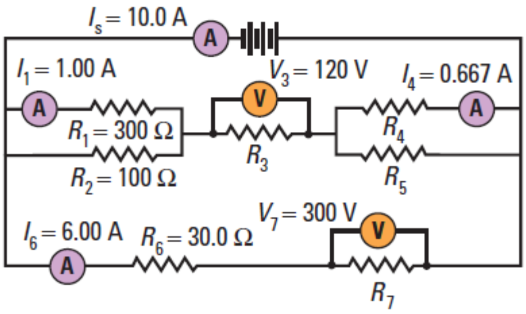
50. A floodlight filament has an operating resistance of 22.0 Ω. The lamp is designed to operate at 110 V.

(a) What is its power rating?

(b) How much energy is consumed if you use the lamp for 2.50 hours?

PRACTICE PROBLEMS MHR Pg. 748

18. In the circuit diagram below, values for some of the quantities for each part of the circuit are given. Calculate the missing currents, resistances, and the potential differences for each of the loads in the circuit. Find the equivalent resistance for the circuit and the power output for the circuit.



29. A load, R_1, is connected in series with two loads, R_2 and R_3, which are connected in parallel with each other. If the potential difference of the power supply is 180 V, find the current through and the potential difference across each of the loads. The loads have resistances of 25.0 Ω, 30.0 Ω and 6.00 Ω, respectively.

30. A motor draws a current of 4.80 A from a 36.0 V battery. How long would it take the motor to lift a 5.00 kg mass to a height of 35.0 m? Assume 100% efficiency.

31. A 45.0 m extension cord is made using 18 gauge copper wire. It is connected to a 120 V power supply to operate a 1.0×10^2 W-120 V light bulb.

(a) What is the resistance of the extension cord? (Remember that there are two wires to carry the current in the cord.)

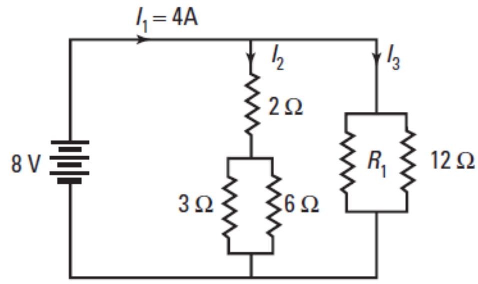
(b) What is the resistance of the filament in the light bulb?

(c) What is the current through the cord to the light bulb?

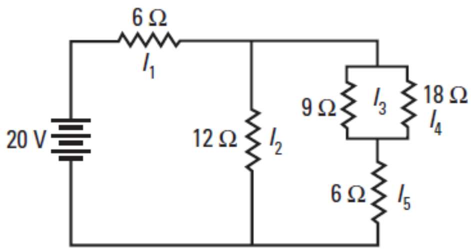
(d) What is the actual power output of the light bulb?

32. When a battery is connected to a load with a resistance of 40.0 Ω, the terminal voltage is 24.0 V. When the resistance of the load is reduced to 15.0 Ω, the terminal voltage is 23.5 V. Find the *emf* and the internal resistance of the battery.

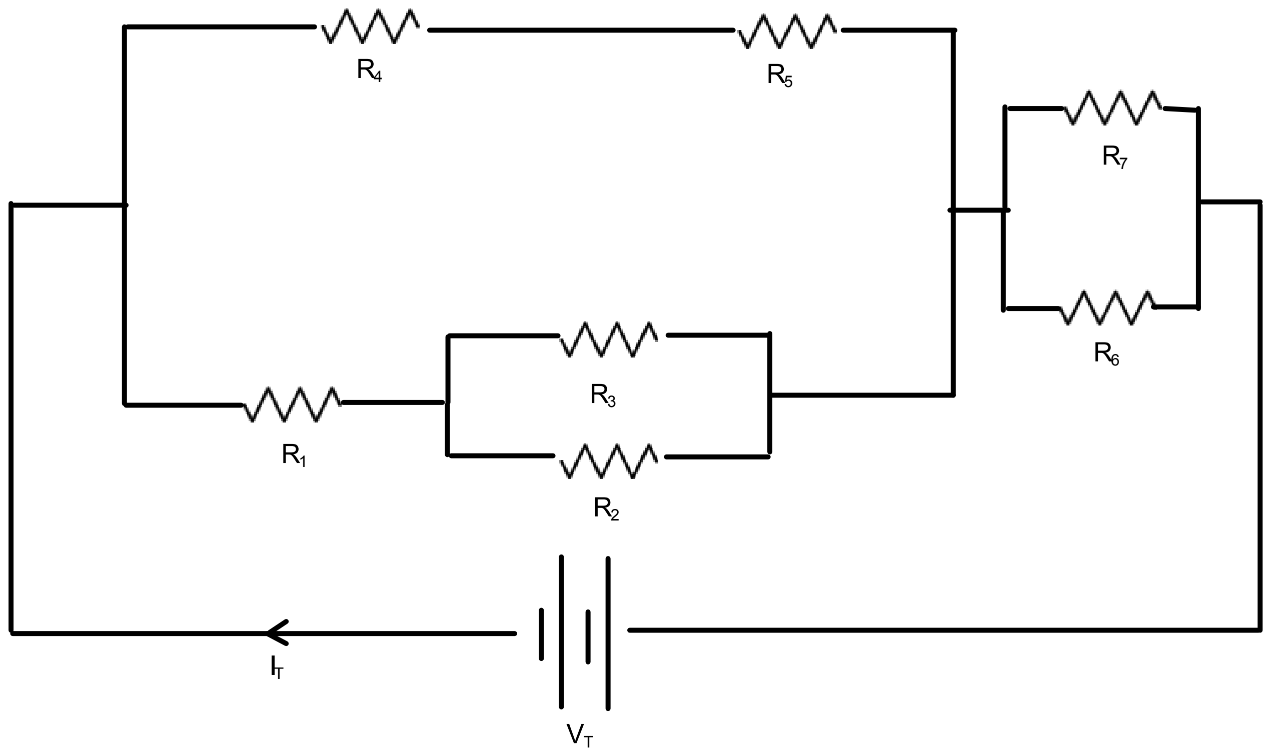
33. Find all of the missing currents and resistances and the equivalent resistance of the circuit.



34. Find all of the equivalent resistance of the circuit and the current through each resistor.

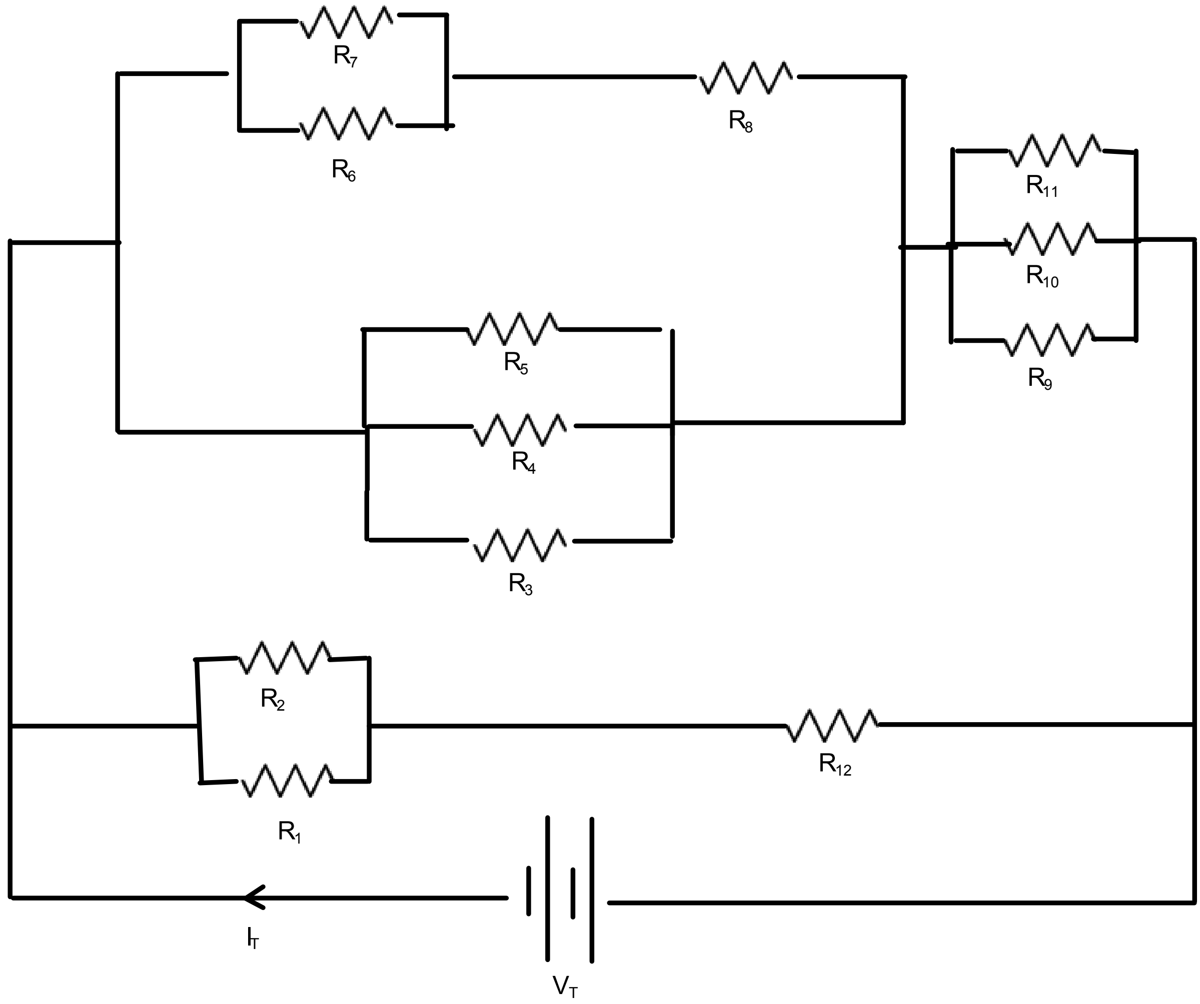


Practice: Fill in the V - I - R table given each resistor and the voltage of the battery.



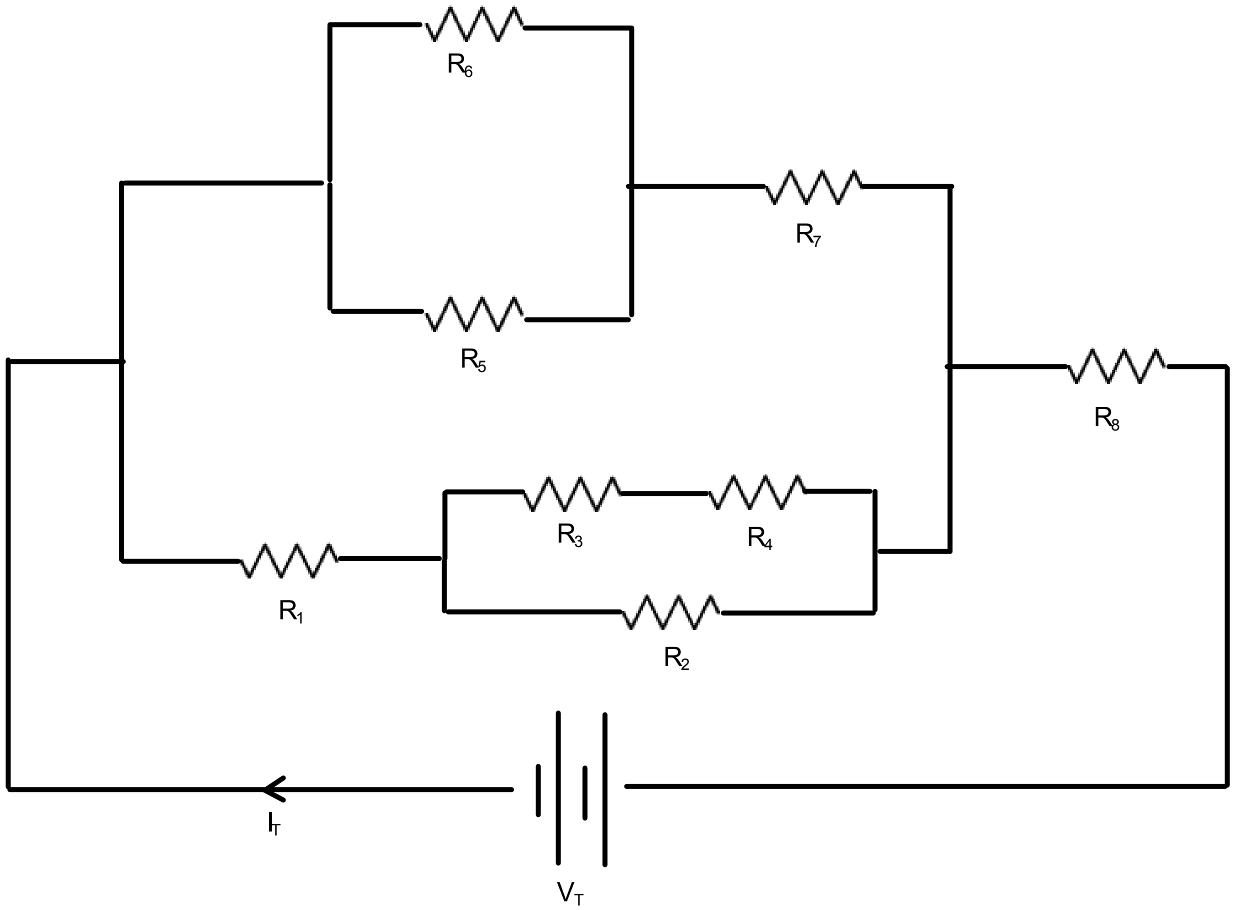
#	V (V)	I (A)	R (Ω)
1			3.0
2			8.0
3			4.5
4			2.5
5			5.5
6			6.0
7			6.0
	$V_T = 60$	$I_T =$	$R_{eq} =$

Practice: Fill in the V - I - R table given each resistor and the voltage of the battery.



#	V (V)	I (A)	R (Ω)
1			3.0
2			8.0
3			4.5
4			2.5
5			5.5
6			6.0
7			8.5
8			3.5
9			2.5
10			9.0
11			5.0
12			3.5
	$V_T = 70$	$I_T =$	$R_{eq} =$

Fill in the V - I - R table given each resistor and the voltage of the battery.



#	V (V)	I (A)	R (Ω)
1			2.0
2			5.0
3			4.0
4			6.5
5			3.0
6			2.0
7			1.5
8			3.5
	$V_T = 40$	$I_T =$	$R_{eq} =$

Practice Problems and Chapter and Unit Review Problems

Chapter 1 Review

Problems for Understanding

15. 2.6%

16. (a) 0.03%

17. (a) 11.5 Hz
(b) 11 Hz
(c) 11 Hz

Chapter 2

Practice Problems

1. –1.0 m/s

2. 1.2 m/s[N57°W]

3. (a) 0.29 m/s **(b)** 75 m or 175 m
(c) 75 m **(d)** 0.87 m/s

4. for linear segments: 2.5 m/s, –7.5 m/s, 0.0 m/s, 3.8 m/s

Chapter 2 Review

Problems for Understanding

15. (a) with respect to the ground
(b) with respect to the truck

17. (a) 17 km **(b)** 7.0 km[S]
(c) 7.0 km[N]

18. 26 km[W]

19. (a) 0.40 km [downstream]
(b) 0.53 km/h [downstream]

20. 4.35 years

21. (a) 11.4 km from Vectorville
(b) 0.571 h or 34.2 min

22. (a) uniform **(b)** non-uniform
(c) non-uniform **(d)** non-uniform
(e) uniform

24. -2.8 m/s^2

25. 2.7 m/s, 0.45 m/s^2

26. 2.0×10^1 m[E] from the foul line

28. (1) 0 to 3.0 s, **(2)** 3.0 to 8.0 s, **(3)** 8.0 to 12 s, **(4)** 12 to 18 s

30. (a) 41 km
(b) 28 km[W28°N]
(c) 46 km/h
(d) 31 km/h[W28°N]

Chapter 3

Practice Problems

1. 8.0 m/s^2

2. 2.5 m/s^2[up]

3. 24 m/s

4. (a) 5.0 m **(b)** 1.6 m/s^2

5. 34 s

6. 6×10^2 m

7. 10 m/s

8. (a) 4.0×10^2 km[E28°N]
(b) W28°S

9. (a) 5.0 km **(b)** E37°S

10. 5.8 km[18° away from the horizontal from the lookout]

11. (a) 62.6 km [W11.3°N]
(b) E11.0°S

12. (a) (i) 27 km[N] **(ii)** 24 km[N12°E]
(iii) 24 km[S12°W]
(b) (i) 27 km[N] **(ii)** 24 km[N12°E]
(iii) 6.0 km[W34°N]

13. 67 km/h [W48°N]

14. 346 km/h[E30.0°N]

15. 10 m/s in direction 7° away from the normal to the boards, towards the puck's initial direction

16. (a) 8.4 m/s[N7.1°W]
(b) 5.5 m/s[N40°E]
(c) 3.6 m/s[E57°N]

17. 5.7 km/h[S42°W]

18. (a) 48 km/h[W29°N]
(b) 1.2×10^2 km/h [E29°S]

19. 5.8×10^3 m[N23°W]

20. (a) 9.2 km[N24°W]
(b) 3.1 km/h[N24°W]

21. 1.8 m/s[downstream]

22. 12 m/s[S24°W]

23. (a) N20.5°E
(b) 227 km/h[N30.0°E]
(c) 1.10 h

24. (a) 1.6×10^2 km[W18°N]
(b) 3.0×10^2 km/h[N], 2.2×10^2 km/h[W], 2.5×10^2 km/h[S]
(c) 1.3×10^2 km/h[W18°N]

25. (a) N25°E **(b)** 69 s

26. (a) 2.1 km[W54°N]
(b) S54°E
(c) 2.4 h

27. (a) 1.6 m/s[E18°S]

Chapter 3 Review

Problems for Understanding

11. 3 m/s

12. –1.9 m/s

13. (a) 17 m/s **(b)** 2.8 m/s^2

14. (a) 27 m **(b)** 8.0 m/s

15. (a) -1.2 m/s^2 **(b)** 6.9 s

16. 1.2×10^2 m[down]

17. (a) 23 s **(b)** 550 m

18. (a) 71 km/h[SW]
(b) 3.9 m/s^2[SW] or 5.1×10^4 km/h^2[SW]

19. (b) 3.6 km[S34°W]

20. (a) 6.6 km[N31°W]
(b) 4.4 km/h[N31°W]

21. (b) 7.9 m/s[NW]

22. (a) 18 km[W24°S]
(b) 14 km/h[W24°S]

23. (a) 1.3 m/s[N] **(b)** 3.7 m/s[S]

24. (a) [E26°N] **(b)** 1.7 m/s[E]
(c) 47 min

25. 4.4 m/s[N5.4°E]

26. 12 km[W24°N]

27. (a) 2.0×10^1 km[N16°E]
(b) 9.9 km/h[N16°E]

28. 0.217 m/s^2[S19.7°W]

29. (a) He should aim upstream at an angle 41° with respect to the river bank.
(b) 2.3 min

Unit 1 Review

34. 13 km[E13°S]

35. 64 km/h[E51°S]

36. (a) 0.50 h **(b)** 55 km[S]
(c) 110 km/h[S]

37. (i) B **(ii)** C **(iii)** A **(iv)** D

38. (a) 3.7×10^2 km **(b)** 79 km/h

39. 7.2 s

41. (a) 0.4 km **(b)** 6 min
(c) 1 km

42. 2.5 m/s^2[N]

43. 5.0×10^1 m

44. 9.0 s

45. 20 s

46. (i) A **(ii)** C **(iii)** E

47. (a) 5.1 km[S28°E]
(b) 1.7 m/s[S28°E]

48. 1.8 m/s[N19°E]; 8.8×10^2 s; 5.3×10^2 m downstream

49. (a) 7.4 m/s[N] **(b)** 9.5 m/s[N]
(c) 5.3 m/s[N]

50. (a) Deke **(b)** 6.2 min

51. 4.9×10^2 m

53. 59 km/h[E17°S]

54. 45 km/h[E45°S]

55. Heading[N23.5°W]; 201 m/s[N30.0°W]

56. 1.9×10^4 m/s^2[N]

57. 6.8 m/s^2[NW]

58. 3.9 m/s[NE]

Chapter 4

Practice Problems

1. 23 N
2. (a) 66.722 kg (b) 656.03 N (c) 605.81 N
3. $W_{Earth} = 2.05 \times 10^3$ N, $W_{Moon} = 3.43 \times 10^2$ N
4. 3.25×10^{-2} m/s^2
5. (a) 5.89 N (b) 3.50 N; 0.595 (c) μ_k
6. (a) 1.23×10^3 N (b) 527 N (c) 264 N
7. 1.95×10^2 N
8. 0.34

Chapter 4 Review

Problems for Understanding

26. 11 kg
27. 90.4 N, 205 N
28. 1.2×10^2 N
29. 62%
30. 0.87
31. 2.0×10^2 kg
32. 49 N
33. 37.5% or a 171 N reduction
34. (a) 4.4×10^3 N (b) 1.5×10^3 N (c) 0.25

Chapter 5

Practice Problems

1. 0.55 m/s^2[E]
2. 0.53 m/s^2[E]
3. 1.7 kg
4. 1.6 m[N]
5. (a) 5.6 m/s^2[E] (b) 2.0×10^2 m[E]
6. 0.23
7. 9.6×10^{-13} N
8. 9.3 m/s
9. –7.7 m/s^2
10. (a) 0.249 N (b) 0.00127
11. 78 N
12. (a) 58 N (b) 16 m/s^2
13. 6.7 m
14. 40 N[N30°E]
15. (a) 43 N[E] (b) 7.4 N[N] (c) 15 N[E] (d) 15 N[W28°S]
16. (a) 1.4×10^3 N (b) 3.9×10^2 N
17. (a) $F_x = 120$ N, $F_y = -86$ N (b) 3.3×10^2 N (c) 38 N (d) 1.5 m/s^2
18. 1.6×10^3 N, 9.1×10^2 N
19. (a) 21 N (b) 15 N
20. (a) 74 N (b) 34 N
21. negative; 5.9×10^2 N
22. down (negative); 6.9×10^2 N
23. up (positive); 5.9×10^2 N
24. 15 m/s
25. (a) 1.2 m/s^2 (b) 0.16 m/s^2 (c) 12 s
26. 0.061
27. 0.34 m
28. 0.37
29. (a) 11.5 kg m/s[E] (b) 2.6×10^8 kg m/s[W] (c) 8.39×10^7 kg m/s[S] (d) 5.88×10^{-24} kg m/s[N]
30. 43.6 N·s[down]
31. 2.58×10^5 N·s[S]
32. 4.52×10^6 N[S]
33. 2.6 kg m/s[forward]
34. –38 kg m/s
35. 8.8 kg m/s[up]

Chapter 5 Review

Problems for Understanding

24. 0.4 m/s^2
25. (a) 3.8×10^2 N (b) 0.18 m/s^2
26. 50 N[E70°N]
27. (a) 0.80 m/s^2 (b) 16 N
28. (a) $v = 0$; $a = -9.8$ m/s^2 (b) 3.5 m/s; –9.8m/s^2
29. (a) 1.34 m/s^2 (b) 334 N
30. 1.2 N
31. (a) 0.062 m/s^2 (b) 0.40 m/s^2 (c) A friction force of magnitude 3.4 N operates to reduce the ideal acceleration ($a = F/m$)
32. 11 m
33. (a) 5.4 m/s[down] (b) 3.7×10^4 N[up]
34. 1.3 m/s^2
35. (a) $a_2 = 2.5a_1$ (b) $d_2 = 2.5d_1$
36. (a) 9.00 N (b) –132 N (c) 141 N (d) 0.451
37. 18 kg m/s[N]
38. 1.5×10^3 kg
39. 1.20 m/s[S]
40. 6.0×10^3 m/s[forward]
41. (a) 0.023 N·s[E] (b) 0.036 N·s[S]
42. 3.8×10^3 N
43. 3.6×10^{-2} s
44. (a) 16 kg m/s[S] (b) 6.4×10^{-3} s
45. 2.5×10^4 N[E]
46. 2.9×10^4 N[backward]

Unit 2 Review

29. (a) 4.70×10^2 N (b) 178 N (c) 1.24×10^3 N
30. (a) 3.7×10^2 N (b) 1.9×10^2 N
31. (a) 62 N (b) 31 N
32. 4.60×10^3[E]
33. 89.7 kg
34. 0.441 m/s[E0.0121°N]
35. (b) It would accelerate in the horizontal direction. (c) It would have constant velocity. (d) It would slow down and stop.
36. 1.2×10^2 N[up]
37. (a) 2.00 (b) 2.00
38. (a) 1.5×10^4 N (b) 3.8×10^3 N (c) 2.5 m/s^2 (d) 22 m/s = 81 km/h (e) 9.0 s
39. 2.0×10^2 N
40. 6.9×10^3 N
41. (a) 612 N (b) 437 N (c) 786 N (d) 612 N
42. (a) 1.7×10^2 N (b) 29 m/s
43. (a) 2.74×10^3 N[W] (b) 1.05×10^3 N[W]
44. 3.5×10^4 kg m/s[N]
45. (a) 6.6 kg m/s (b) 4.0×10^1 kg m/s (c) 3.0×10^3 kg m/s
46. (a) 9.6 kg m/s[N] (b) –17 kg m/s[N] (c) 17 kg m/s[S] (d) 2.6×10^2 N[N] (e) 2.6×10^2 N[S]
47. (a) 45 N (b) 42 m/s

Chapter 6

Practice Problems

1. 5.7×10^3 J; 42 m
2. 82 m
3. 2.30 m/s^2
4. 6.33 m
5. 225 N
6. 10.9 m
7. (a) 0 J (b) force is perpendicular to direction of motion
8. 3.00×10^2 J
9. (a) 0 J (b) no forces are acting so no work is done (velocity is constant)
10. (a) 0 J (b) the tree did not move, so Δd is zero

11. A. 180 J B. 65 J
C. 0 J D. ~230 J

14. (a) 4.1×10^3 J (b) -4.1×10^3 J
(c) gravity and applied force

15. raising: +126 J; lowering: –126 J

16. 1.9×10^3 J

17. 1.4×10^2 N

18. 40.0°

19. 81.1 J

20. 1.0×10^1 kg

21. 1810 J

22. 11.5 m/s

23. 4.1×10^6 m/s

24. 0.36 J; 3.6 N 6.35 kg

25. 6.35 kg

26. 3000 N; 40 M; 160 m; $d \propto v^2$

27. 87 J

28. 2.4×10^6 J

29. 4.08 m

30. 1.16 m

31. (a) 2370 J (b) 2370 J

32. 16.0 J

33. 1.51×10^6 J

34. (a) 1.59×10^5 J (b) 2.38×10^5 J
(c) 3.97×10^5 J

35. 5×10^2 N/m

36. (a) 0.414 m (b) –455 N

37. 0.0153 kg

38. 1.0 J

39. 0.30 m

40. 1.4 J

41. 1.5×10^2 W

42. 15.4 kW; 20.7 hp

43. No, the student will be 1.15 s late

44. (a) 75%
(b) into friction of moving parts

45. 25.5%

46. 19.0%

47. (a) $Eff_{incand} = 4\%$, $Eff_{fl} = 8\%$
(b) the florescent bulb heats up less than the incandescent bulb

48. 87.2%

49. (a) 66.3 J (b) 6.01 J (c) 90.9%

50. 34%

Chapter 6 Review

Problems for Understanding

15. (a) Ground pushes up, gravity pulls down, engine propels car forward, ground resists backward.
(b) The forward force (from the car's engine) does work.

16. 44 N

17. 3.50×10^2 J

18. 1.44×10^4 J

19. 6.2×10^2 J

20. 4.38 J

21. 5.0 m: 1.0×10^2 J, 13 m/s;
15.0 m: 5.8×10^2 J, 31 m/s;
25.0 m: 8.1×10^2 J, 36 m/s

22. 73°

23. the 55 kg athlete

24. (a) 3.2 m/s; 3.4×10^2 J

25. 5.0×10^1 kg

26. (a) 0.035 N (b) –0.025 J
(c) 0.025 J

27. (a) 16 J (b) 16 J

28. (a) 7.7×10^3 J (b) 6.7×10^3 J
(c) 9.4 m/s; 8.7 m/s
(d) infinity (no friction); 1.3×10^2 m

29. 2.6×10^3 J

30. 4.5×10^2 N/m

31. (a) 0.38 J (b) 9.6 N

32. 3.6 m/s

33. 2.3 m/s

34. 0.45 m

35. 0.096 m

36. 3.5×10^2 W

37. (a) 2.7×10^5 J (b) 2×10^6 J
(c) 4×10^6 J (d) 4.5×10^9 J

38. (b) 1.0 m/s^2 (c) 4.6 m
(d) 56 J (e) 18 W

39. 5 kW

Chapter 7

Practice Problems

1. 13 m/s
2. 7.7 m
3. 4.8 m
4. 5.1 m
5. $E_g = 4140$ J; $E_k = 4140$ J; $v = 5.12$ m/s
6. ball: 610 J, 22 m/s; shot: 13 J, 22 m/s
7. 1.0×10^1 m
8. 15 floors; 49.3 m/s 152 J
9. (a) 0.28 m (b) 1.3 m/s
(c) 17 m/s^2
10. 1.4×10^3 N/m
11. 57 m/s
12. (a) 80.4 m/s (b) 5.98 m/s
13. (a) 39.6 cm (b) 16.9 J
14. (a) 469 g (b) 65.2 cm
(c) 61.3 cm
15. 6.59×10^3 N/m
16. 0.42 m
17. (a) 405 N/m (b) 44.1 m/s^2
18. 11 m/s
19. 14.3 m/s
20. 7.40×10^2 J
21. (a) 11 J (b) 6.7 m/s
(c) 4.2 m/s
22. –7.4 J; –180 N
23. 43.1 m/s; 8.9%
24. 75 N
25. 2.7 m/s
26. 0.11 m/s[in the direction that car A was travelling]
27. 2.10 m/s[S]
28. 0.11 m/s[E]
29. -2.43×10^2 m/s
30. $v_2 = 6.32$ m/s[41.5° counterclockwise from the original direction of the first ball]; the collision is not elastic: $E_k = 12.1$ J; $E_k' = 10.2$ J
31. 1.24×10^5 kg km/h = 3.44×10^4 kg m/s[N39.5°W]; the collision was not elastic: $E_k = 3.60 \times 10^6$ kg km^2/h^2; $E_k' = 1.80 \times 10^6$ kg km^2/h^2

Chapter 7 Review

Problems for Understanding

20. 0.36 m
21. 17 J; 4.2 m/s
22. 30 m/s
23. 1.3 m/s
24. 0.77 m/s; 0.031 m
25. 5.0 m/s
26. (a) -8.7×10^2 J (b) –1.8 m
27. 3.1 m/s[E]
28. –2.3 m/s
29. 1.3 m/s[forward]
30. 0.17 m/s[forward]
31. (a) 0.21 m/s (b) 13 kg·m/s
(c) 95%

Unit 3 Review

38. 16.8 m/s
39. 31 m/s, 22 m/s, 18 m/s
40. (a) -5.8×10^3 J (b) 3.6
(c) yes, $\mu > 1$
41. (a) 6.1×10^3 N (b) 1.8×10^7 J
42. (a) 1.3×10^4 kg m/s
(b) -1.3×10^4 kg m/s
(c) -1.3×10^4 kg m/s
(d) 19 m/s
43. 260 m/s
44. (a) 780 J (b) It loses 780 J

45. -7.9×10^3 N

46. **(a)** 0.24 J **(b)** 48 J

47. **(a)** 0.32 m **(b)** 12 J

48. 15 kg

49. 60.0 m

50. **(a)** 1.46×10^4 J
(b) 1.46×10^4 J; 12.5 m/s

51. 3.1 m/s

52. **(a)** 0.47 m

53. **(a)** 6.0 N **(b)** 0.15 J **(c)** 0.023 J

54. 1.16×10^3 J. No, work is done by friction forces.

55. **(a)** 4.4 m/s **(b)** 3.5 m/s

Chapter 8

Practice Problems

1. 0.98 Hz; 1.0 s

2. 7.5 to 11 Hz

3. 29.7 s

4. 0.04 Hz; 2.5 s

5. 7.5 m/s; 0.80 s

6. 1.4×10^9 Hz

7. 3.1×10^{-4} Hz

8. **(a)** 8.80 Hz **(b)** 853 m
(c) constant frequency

9. **(a)** 1.34 m **(b)** 0.670 m

Chapter 8 Review

Problems for Understanding

21. 0.25 Hz

22. the wavelength doubles

23. 0.4 m

24. 1.67×10^{-2} Hz; 5.72 m

25. **(a)** 1.4 Hz **(b)** 3.7 cm/s

26. 1.6 Hz

27. 680 km

28. **(a)** 1.2 Hz **(b)** 0.84 s

29. **(a)** 1.02 s **(b)** 2.56%
(c) 225 h or 9.38 days
(d) shorten the pendulum

Chapter 9

Practice Problems

1. **(a)** 3.5×10^2 m/s **(b)** 3.4×10^2 m/s
(c) 3.5×10^2 m/s **(d)** 3.2×10^2 m/s

2. **(a)** 35.6 °C **(b)** 11.9 °C
(c) 5.1 °C **(d)** –20.3 °C

3. **(a)** 6.2×10^2 m

4. 0.005 s

5. 2.0×10^2 m

6. **(a)** 5.8 s **(b)** 6.7×10^{-6} m
(c) 2.8 km

7. 1.31, ice

8. 29.7°

9. 51°

10. 39.5°

11. 31.0°

12. 47.2°

13. 58.9°

14. 78.5°

15. 2.6 m

16. **(a)** 68 cm **(b)** 85 cm

17. **(a)** 96 cm, 160 cm
(b) 64 cm, 96 cm

18. 19 cm, 57 cm

19. 32 cm, 96 cm

20. **(a)** 1.34 m **(b)** 64 Hz

21. 512 Hz, 768 Hz

22. **(a)** 64.9 Hz **(b)** 130 Hz, 195 Hz

23. **(a)** 175 Hz **(b)** 1.97 m

24. **(b)** 6.00 Hz

25. 9.0 beats

26. 251 Hz or 261 Hz

27. **(a)** 443 Hz

Chapter 9 Review

Problems for Understanding

40. **(a)** 307 m/s **(b)** 3.3×10^2 m/s
(c) 343 m/s **(d)** 352 m/s

41. **(a)** 40.7 °C **(b)** 22.0 °C
(c) 3.39 °C **(d)** –22.0 °C

42. 4.0 °C

43. 7.0×10^2 m

44. **(a)** 436.5 Hz or 443.5 Hz
(b) If, as the string is tightened, the beat frequency increases, then the guitar was at 443.5 Hz, while if the beat frequency decreases, then the guitar was at 436.6 Hz.

45. **(a)** The human brain responds to harmonics, i.e. simple fraction ratios of pitch.

46. **(a)** Increases in pitch at specific, well-defined tube lengths.
(b) $L_1 = 0.098$ m, $L_2 = 0.29$ m, $L_3 = 0.49$ m, $L_4 = 0.68$ m

47. **(a)** 0.38 m **(b)** 9.0×10^2 Hz

48. The well is less than 176 m deep.

49. 0.062 m

50. 2.8×10^3 km/h

51. 1.3×10^2 m

52. Yes, with 0.03 s to spare.

53. **(a)** 55° **(b)** 110°

54. 56°

55. 38°

56. 1.95

57. 22.8°

58. The ray exits at 30°, 5.7 cm from the bottom corner (assuming it entered 3.5 cm from the same corner).

59. 2.4×10^{-9} s

60. **(a)** 1.2 **(b)** 11° **(c)** 39°

61. 22°

62. 68°

63. 4 cm

64. 4.8×10^2 nm

65. 589 nm

Unit 4 Review

Problems for Understanding

39. 3.0 m/s

40. 0.167 Hz

41. 0.8 m

42. 7.14×10^9 Hz

43. 0.73 m

44. 312 Hz

45. 0.259 m

46. 382.8 Hz or 385.2 Hz

47. 2.4 s

48. 2.00 m

49. –8 °C

50. 1.60×10^8 m/s

51. 1.0×10^{-9} s

52. 1.4

53. 25°

54. 15°

55. 1.39

56. 60°

57. 38.6°

58. 0.12 m; 2.5×10^9 Hz; 4.0×10^{-10} s

59. 2.1×10^5 Hz; 1.4×10^3 m

60. 5.5×10^{16} cycles

61. 1.5×10^2 m

62. 9.4607×10^{15} m

63. 8×10^{-7} m

Chapter 10

Practice Problems

1. **(a)** 4.1 m, 15 m
(b) -6.6 m/s^2, 4.6 m/s^2
(c) –11.3 m/s, –11.3 m/s

2. **(a)** 6.84 km, 18.8 km
(b) 2.6 m/s, –1.5 m/s
(c) –2.3 m/s, 6.4 m/s

3. 3.0×10^1 km[E], 5.2×10^1 km[N]

4. **(a)** 5.9 km[E34°?]
(b) [W56°N]

5. **(a)** W17°S
(b) 8.7 min

6. 15 m/s in a direction 4.9° to the shuttle
7. (a) 1.6×10^2 N[W58°S]
(b) 2.1×10^2 N[W16°N]
(c) 1.3×10^2 N[S50°W]
8. (a) 1.6×10^2 N[W58°S]
(b) 2.1×10^2 N[W16°N]
(c) 1.3×10^2 N[S50°W]
9. 1.5×10^3 N by each cable
10. (a) No (b) $> 1.7 \times 10^2$ N
11. (a) 20° (b) 0.028 m/s^2
12. 4.0×10^2 N
13. (a) $> 8.3 \times 10^2$ N (b) $> 7.3 \times 10^2$ N
14. –1.9 m/s^2
15. No, the climber must limit his descent to $a = -2.5$ m/s^2
16. (a) downward (b) –1.1 m/s^2
(c) 87 N
17. 1.7×10^2 N
18. 1.8 m/s^2
19. 0.49 m/s^2; 39 N
20. 14 kg; 75 N
21. 62 kg; 1.6 m/s^2
22. 17 N
23. Both of them will rise, with $a = +1.0$ m/s^2
24. (a) 3.88 N (b) 2.04 m/s^2
25. 0.67 s
26. 2.77 s
27. (a) 0.69 m/s (b) 0.81 N
28. (a) 0.91 N (b) 0.87 m/s^2
(c) 5.3 N
29. 65 N·m
30. 5.1×10^2 N·m
31. 1.1×10^3 N
32. 9.6×10^2 N
33. (a) 4.3×10^2 N (b) 6.7×10^2 N
34. 4.4×10^2 N
35. 6.4 m/s[40.0° counterclockwise]
36. 1.16 m/s[6.1° clockwise from original direction]
37. V_A = 34.3km/h[S];
V_B = 67.km/h[E]
38. 1.4 Kg, 2.6 m/s [83° counterclockwise from the x-axis]
39. V_2 = 6.32 m/s[41.5° counterclockwise from the original direction of the first ball]; the collision is not elastic: E_k = 12.1 J; E'_k = 10.2 J
40. 1.24×10^5 kg km/h =
3.44×10^4 kg m/s[N39.5°W];
the collision was not elastic:
$E_k = 3.60 \times 10^6$ kg km^2/h^2;
$E'_k = 1.80 \times 10^6$ kg km^2/h^2
41. 261 m/s
42. The cart will stop at 0.018 m; therefore, it will not reach the end of the track.
43. 55.5 km/h = 15.4 m/s
44. 18.2 m/s
45. 3.62 m/s; 1.71 m

Chapter 10 Review

Problems for Understanding

23. (a) N36°E (b) 1.5 m/s[E]
(c) 29s
24. (a) 1.0×10^2 N[E27°N]
(b) 34 N[S0.61°E]
(c) 1.5×10^2 N[67° counterclockwise from the x-axis]
25. 2.3×10^2 N [1.4° to the right of backward]
26. (a) No (c) 2.8 kg (d) 5.7 m/s^2
27. 3.9×10^2 N[up], 5.0×10^2 N[up]
28. (a) 8.58×10^3 N
(b) 1.00×10^4 N[43.3° cw from arm]
29. 4.4 m/s[35.2° clockwise]
30. (a) 0.29 m/s[W21°N]
(b) 70%

Chapter 11

Practice Problems

1. 677 m [before drop point]
2. 4.67 m/s
3. 89.6 m, 45.2 m/s [60.3° below the horizontal]
4. 0.156 m
5. 3.05 m/s
6. 0.55 m
7. 74 m
8. (a) 153 m
(b) 5.00 m/s [down]
9. 85 m
10. 4.0×10^1 m
11. 18 m/s [52° below the horizontal]
12. 2.8 m/s
13. (a) 58.9 m (b) 21.0 m (c) 4.14 s
14. 33.2°; 2.39 m; 1.40 s
15. 47.0 m/s
16. 2.7×10^2 m
17. (a) 48.6 N (b) 54.2 N (c) 9.62 m/s
18. 5.9×10^3 N
19. 84 m
20. 103 m
21. 13 m/s (47 km/h)
22. 19.1 m/s (68.8 km/h)
23. 20.1°

Chapter 11 Review

Problems for Understanding

15. (a) 3.0×10^1 m (b) 3.7 s
16. 2.7×10^2 m
17. (a) 2.1 s (b) 34 m
(c) 8.5 m [above the ground]
(d) v_x = 16 m/s; v_y = +3.8 m/s or –3.8m/s
(e) 38.2°
18. 52 m/s
19. Yes. It travels 330 m.
20. (a) 7.4 s (b) 67 m
(c) 1.2×10^2 m (d) x: 34 m, y: 53 m
(e) v_x = 17 m/s; v_y = –23 m/s
21. (a) 2.1 m/s (b) 1.2 m/s^2
22. (a) 1.33×10^{14} m/s^2
(b) 1.21×10^{-16} N
23. 0.33
24. 8.9 m/s
25. 33°
26. 9.90 m/s
27. 0.62
28. (a) 4.64×10^2 m/s
(b) 2.0 N (for m = 60.0 kg)
(c) Toward the centre of Earth; gravity
(d) mg = 589 N (for m = 60.0 kg)
(e) $N = mg - mv^2/r$ = 587 N
(f) $mg - N = ma_c$; because $mg > N$, there is a net acceleration toward the centre of Earth.

Chapter 12

Practice Problems

1. 3.58×10^{22} N
2. 1.99×10^{20} N
3. 5.1×10^{-3} m. This is much smaller than the radii of the bowling balls.
4. 3.61×10^{-47} N
5. 5.0×10^{24} kg
6. 0.25 m
7. $F_{Uranus} = 0.80 \times F_{Earth}$
8. 0.9 × Earth – Moon distance
9. 1.899×10^{27} kg
10. 1.472×10^{22} kg
11. 2.74×10^5 m
12. 1.02×10^3 m/s
13. (a) 6.18×10^4 s (17.2 h)
(b) 7.93×10^2 m/s
14. 4×10^{41} kg = $2 \times 10^{11} \times M_{Sun}$
15. 7.42×10^3 m/s; 8.59×10^5 m
16. 7.77×10^3 m/s; 5.34×10^3 s (89.0 min)

17. **(a)** 5.21×10^9 s (165 years); 5.43×10^3 m/s
(b) It will complete one orbit, after its discovery, in the year 2011.

Chapter 12 Review

Problems for Understanding

22. 1/8
23. **(c)** F
24. **(b)** a/3
25. **(a)** 3.0×10^4 m/s
(b) 6.0×10^{-3} m/s^2
26. 1.8×10^{-8} m/s^2
27. 9.03 m/s^2 = 92% of acceleration due to gravity at Earth's surface
28. 4.1×10^{36} kg $= 2.0 \times 10^6 \times m_{Sun}$
29. 2.7×10^{-10} N
30. **(a)** 5.3×10^5 m
(b) 5.7×10^3 s = 95 min
31. 1.02×10^3 m/s; 2.37×10^6 s = 27.4 days
32. **(a)** Yes. **(b)** 5.69×10^{26} kg
33. **(a)** 4×10^{15} kg **(b)** 4×10^{27} kg
(c) $m_{Oort} = 700m_{Earth} = 2m_{Jupiter}$

Chapter 13

Practice Problems

1. 0.494 s
2. 17 N/m
3. **(a)** 0.253 s **(b)** 8.4 m/s
(c) 7.4 m/s
4. 8.2×10^4 N/m
5. **(a)** 71 N/m
(b) 0.897 s using k = 71.05 n/m
6. **(a)** $k = 2.2 \times 10^3$ N/m
(b) 0.98 s
7. 1.3 s
8. 4.0 m
9. 0.25 m
10. 0.88 s

Chapter 13 Review

Problems for Understanding

22. 0.245 s, 0.297 s, 0.42 s, 0.149 s, 0.181 s, 0.26 s
23. 0.48 s
24. **(a)** 0.82 J **(b)** 1.37 m/s
25. **(a)** 81 J **(b)** 8.0×10^2 N/m
(c) 0.13 s
26. 44 N/m
27. 0.21 s
28. 0.016 m
29. 0.097 m
30. 1.5 m/s

Unit 5 Review

33. 15 N[E19°S]
34. 1.4 m/s^2
35. **(a)** 7×10^3 N
(b) $9.15 \times$ true weight
36. 17°
37. **(a)** 9.8×10^2 N **(b)** 13 km
38. **(a)** 33 m/s^2 **(b)** 23 N
39. **(a)** 21.3 m/s **(b)** 1.53 m
(c) down
40. **(a)** 4.4×10^2 N; $1 \times$ weight
(b) 2.0×10^2 N; $0.45 \times$ weight
(c) 4.4×10^2 N; $1 \times$ weight
(d) 6.8×10^2 N; $1.5 \times$ weight
41. 29 m/s
42. 4.2×10^3 m/s
43. **(a)** 4.6×10^2 m/s
(b) 7.9×10^2 m/s
44. 59.7 m
45. 44°
46. **(a)** 0.342 J **(b)** 1.45 m/s

Chapter 14

Practice Problems

1. 0.34 N
2. 0.80 m
3. 5.1×10^{-7} C
4. 0.50 N (attractive)
5. 0.17 N (repulsive)
6. 0.12 m (directly above the first proton)
7. $F_A = 1.2 \times 10^{-2}$ N[W73°S];
$F_B = 1.6 \times 10^{-2}$ N[E63°N];
$F_C = 4.6 \times 10^{-3}$ N[W36°S]
8. 8.7 N[E18°N]
9. 2.0×10^{-8} C
10. 7.9×10^{-8} C
11. 1.5×10^5 N/C (to the right)
12. 0.019 N[W]
13. 2.5×10^4 N/C (to the left)
14. -4.0×10^{-4} C
15. 3.8 N/kg[down]
16. 52 N[down]
17. 3.46 kg
18. 2.60 N/kg[down]
19. 2.60 m/s^2[toward centre]
20. -7.8×10^5 N/C (toward the sphere)
21. -1.2×10^{-5} C
22. 0.32 m
23. 5.80×10^9 electrons
24. -1.5×10^6 N/C (toward the sphere)
25. 0.080 m
26. 5.3×10^8N/C[81.4° above the $+x$-axis]
27. 1.9×10^4 N/C[86.7° above the $+x$-axis]
28. 3.4×10^6 N/C[23.7° above the $-x$-axis]
29. 2.25×10^{14} N/C (toward the negative charge)
30. 2.9×10^7 N/C[73.6° above the $+x$-axis]
31. 5.7×10^{-2} N/kg
32. 3.81×10^7 m
33. 8.09 N/kg[toward centre]
34. 5.82×10^{23} kg
35. 5.0×10^{-11} N/kg[toward centre]
36. 8.09 N/kg[toward centre]
37. 1.03×10^{26} kg
38. -4.7×10^{-2} J
39. 0.18 J
40. 5.1×10^2 m
41. 1.55×10^{-4} C. The signs of the two charges must be the same, either both positive or both negative.
42. 4.8×10^6 N/C
43. 1.5×10^{10} m
44. 2.9×10^{-5} J
45. -4.7×10^{-12} C
46. If the positive charge is placed at 0.0 cm and the negative charge is placed at 10.0 cm, there are two locations where the electric potential will be zero: 6.2 cm and 27 cm.
47. 1.1×10^6 V
48. 8.0 V
49. -2.1×10^6 V
50. 1.6×10^6 V
51. 1.4×10^{-6} C
52. 2.0 V
53. 12 J
54. -2.4×10^4 V
55. **(a)** 1.9×10^5 V
(b) 1.2×10^{-3} J
(c) A. It takes positive work to move a positive test charge to a higher potential. Since in this case, you invest positive work to move your positive test charge from B to A, A must be at a higher potential.
56. 5.3 cm and 16 cm to the right of the positive charge.
57. any point lying on a line midway between the two charges and perpendicular to the line that connects them
58. The potential is zero 3.4 cm above the origin and 24 cm below the origin.

59. If the distances of the first and second charges, q_1 and q_2, from the point of zero potential are d_1 and d_2, then d_2 must satisfy $d_2 = (-q_2/q_1)d_1$, with $q_2 > 0$. For example, if $q_2 = -8.0\mu C$, then $d_2 = 16$ cm and the charge would be located either 24 cm to the right of q_1 or 8.0 cm to the left of q_1. Other solutions can be similarly determined.

60. 4.0 cm to the right of the $-4.0\mu C$ charge.

Chapter 14 Review

Problems for Understanding

18. 9×10^3 N
19. 2.3×10^{-8} N
20. 5.6 cm
21. $F_A = 4.5 \times 10^{-2}$ N to the left; $F_B = 0.29$ N to the right; $F_C = 0.24$ N to the left
22. $F_A = 3.8$ N[N3.0°E]; $F_B = 4.4$ N[E23°S]; $F_C = 4.7$ N[W26°S]
23. $F_Q = 8.2 \times 10^{-8}$ N; $F_g = 3.6 \times 10^{-47}$ N
24. The charges on Earth (q_E) and the Moon (q_M) must satisfy $|q_E| \times |q_M| = 3.3 \times 10^{27}$ C^2, and they must have opposite signs.
25. 4.2×10^{42}
26. −57 C
27. 5.2×10^{-3} N
28. **(a)** 8.65×10^{25} kg
 (b) 8.81 N/kg
 (c) 881 N
29. 2/9 g_{Earth} = 2.18 N/kg
30. **(a)** 8.24×10^{-8} N
 (b) 2.19×10^6 m/s
 (c) 5.14×10^{11} N/C
 (d) 27.2 V
31. 1.86×10^{-9} kg $= 2.04 \times 10^{21} \times m_{actual}$
32. 9×10^{-5} N[W]
33. 0.51 m
34. 6.0×10^4 N/C[E37°N]
35. **(a)** -8×10^{-8} J
 (b) It loses energy.
36. -3×10^{-6} J
37. 2.8×10^2 C
38. **(a)** 4.5×10^3 V
 (b) Yes; the spheres have to be at equal potential, because the same point cannot have two different potentials.
 (c) big sphere: 52 nC; small sphere: 23 nC
39. **(a)** E = 0; V = 2.2×10^5 V
 (b) E = 4.3×10^5 N/C; V = 0
40. **(a)** 2.3 J **(b)** 1.2×10^6 V
 (c) X
41. **(a)** 4.0×10^5 V **(b)** R

Chapter 15

Practice Problems

1. 20.0 V
2. 0.378 J
3. 6.5×10^{-2} C
4. 40.0 V
5. 8.0 s
6. 4.23×10^3 J
7. 50 A
8. 57 s
9. 7×10^4 C
10. 2.8 A
11. 4.6×10^7 J
12. 0.133 A
13. **(a)** 9.38 A
 (b) 2.11×10^{22} elementary charges
14. 5.25×10^{20} elementary charges
15. **(a)** 3.3 A **(b)** 1.7 V
16. 2.2 Ω
17. 4.08 m
18. 1.6×10^{-6} m
19. 0.45 Ω
20. 2.4 mm
21. 16 Ω
22. 12.5 A
23. 5.0 V
24. **(a)** 9.9×10^2 C **(b)** 2.1 A
25. 11.6 Ω
26. 7.50 min
27. **(a)** 33 V, 53 V and 79 V respectively
 (b) 75 Ω **(c)** 1.6×10^2 V
28. **(a)** 91.0 V **(b)** 156 V
29. 42.0 Ω
30. **(a)** 8.00 Ω **(b)** 224 V **(c)** 32.0 Ω
31. 44.0 Ω
32. 0.667 A, 1.00 A and 1.33 A respectively; 3.00 Ω
33. $R_{coil} = 6.00$ Ω, $R_{bulb} = 20.0$ Ω, $R_S = 4.62$ Ω
34. $R_{unknown} = 8.00$ Ω, $R_S = 4.80$ Ω
35. **(a)** 11.2 Ω **(b)** 21.6 Ω, 30.0 Ω
36. **(a)** 38.4 Ω **(b)** 2.25 A **(c)** 91.5 V
37. **(a)** 15.4 Ω **(b)** 9.76 V **(c)** 1.02 A
38. **(a)** 14.8 V **(b)** 14.6 V
39. **(a)** 11.4 V **(b)** 11.2 V
40. **(a)** 7.3 A **(b)** 16 Ω
41. **(a)** 6.0×10^1 W **(b)** 27 W
 (c) 1.1×10^2 Ω
42. **(a)** 840 W
 (b) The power output drops to 1/4 its original value, or 210 W
43. **(a)** P_a = 720W, $P_b = 1.6 \times 10^3$ W
 (b) $P_a/P_b = 4/9$; $V_a/V_b = 2/3$; $P_a/P_b = (V_a/V_b)^2$
44. 1.0×10^3 W
45. **(a)** 400 W
 (b) 200 W. Increasing the resistance decreased the current for the given potential difference.
46. 48.0 V
47. 15 Ω
48. 294 W
49. 2.00×10^3 C
50. **(a)** 550 W **(b)** 5.0×10^6 J
51. 3.75 cents
52. 1.08 cents
53. **(a)** 1.4×10^2 W **(b)** 0.50 cents

Chapter 15 Review

Problems for Understanding

24. 3×10^3 Ω
25. **(a)** 12 A **(b)** 2.5×10^3 C
 (c) 3.0×10^5 J
26. 5.0×10^5 J
27. 1.77 cents
28. 37.5 Ω
29. $I_1 = 6.0$ A, $V_1 = 150$ V, $I_2 = 1.0$ A, $V_2 = 3.0 \times 10^1$ V, $I_3 = 5.0$ A, $V_3 = 3.0 \times 10^1$ V
30. 9.93 s
31. **(a)** 1.9 Ω **(b)** 1.4×10^2 Ω
 (c) 0.82 A **(d)** 98 W
32. 24.3 V, 0.517 Ω

Chapter 16

Practice Problems

1. 0.72 N[left]
2. 7.7 N[down]
3. 6.38 A[down]
4. 0.204 T[out of page]

Chapter 16 Review

Problems for Understanding

27. **(a)** 2 times increase
 (b) 9 times increase
 (c) 2 times increase

Unit 6 Review

38. 8.23×10^{-8} N

39. $\pm 14\ \mu C$

40. 1.5×10^4 electrons

41. 1.8×10^{13} C

42. -1.0×10^4 C

43. 0.12 m

44. 9.2×10^{-26} N

45. 1.1×10^{-5} C

46. 6.2×10^{12} electrons

47. **(a)** 0 J **(b)** -8.6×10^{-7} J
 (c) equipotential surfaces

48. 0.10 T

49. 1.2 A (into page)

50. **(a)** 14 N[up] **(b)** 0

51. 4.00 Ω; 1.2 A, 5.0 V

52. Series 5.00 Ω; 1.2 A, 6.2 V
 Parallel 5.00 Ω, 3.8 V; 7.5 Ω;
 5 A, 3.8 V

53. **(a)** 17 V **(b)** 6.5 Ω **(c)** 14 V

Chapter 17

Practice Problems

1. **(a)** 4.8×10^{-13} s **(b)** 1.5×10^{-13} s
2. 257 s
3. $0.94c = 2.8 \times 10^8$ m/s
4. 702 km
5. 0.31 m
6. **(a)** 1.74×10^8 m/s
 (b) The sphere's diameter appears contracted only in the direction parallel to the spacecraft's motion. Therefore, the sphere appears to be distorted.
7. 465 μg
8. 1.68×10^{-27} kg
9. $0.9987c = 2.994 \times 10^8$ m/s
10. 4.68×10^{-11} J
11. 1.01×10^{-10} J
12. 2.6×10^8 m/s
13. 7.91×10^{-11} J
14. 1.64×10^{-13} J
15. 1.3×10^9 J
16. 4.3×10^9 kg/s

Chapter 17 Review

Problems for Understanding

18. $0.87c$

19. **(a)** 3.2 m **(b)** 1.9 m
 (c) 6.8×10^{-8} s

20. **(a)** 2.5×10^{-27} kg **(b)** 1.7×10^{-27} kg

21. plot

22. 3.0×10^2 m/s

23. **(a)** c **(b)** c **(c)** c

24. **(a)** 3.2 **(b)** 5.8×10^{-8} s
 (c) 16 m

25. 1.2×10^{-30} kg, which is 1.3 times its rest mass

26. **(a)** 4.1×10^{-20} J **(b)** 4.1×10^{-16} J
 (c) 1.3×10^{-14} J **(d)** 5.0×10^{-13} J
 (e) (a) and (b)

27. $0.14c = 4.2 \times 10^7$ m/s

28. 3×10^4 light bulbs

29. 4.8×10^{-30} kg; $m/m_o = 5.3$;
 $0.98c = 2.9 \times 10^8$ m/s

30. **(a)** 1.4 g **(b)** 29% or 0.40 g

Chapter 18

Practice Problems

1. **(a)** 2.40 J
 (b) 1.25×10^{15} Hz
 (c) UV
2. 1.26×10^{15} Hz
3. calcium
4. 275 nm $\leq \lambda \leq$ 427 nm
5. 4.28×10^{-34} kg·m/s
6. 9.44×10^{-22} kg·m/s
7. 4.59×10^{-15} m
8. 3.66×10^{25} photons
9. 1.11×10^{10} Hz; radio
10. 1.05×10^{-13} m
11. 7.80×10^{-15} m
12. 1.04×10^{-32} m
13. 2.39×10^{-41} m
14. 5.77×10^{-12} m
15. 2.19×10^6 m/s

Chapter 18 Review

Problems for Understanding

16. **(a)** 1.24×10^{15} Hz

17. **(a)** 2.900 eV
 (b) lithium

18. 1.5×10^{15} Hz

19. 2.2 eV

20. 5.8×10^{18} photons/s

21. **(a)** 1.2×10^{-27} kg m/s
 (b) 1.3×10^{-27} kg m/s
 (c) 9.92×10^{-26} kg m/s

22. 1.7×10^{17} Hz

23. 5.5×10^{-33} kg m/s

24. **(a)** 3.1×10^{-7} m
 (b) 6.14×10^{-10} m
 (c) 4.7×10^{-24} kg m/s

Chapter 19 Review

Problems for Understanding

16. **(a)** 4.8×10^{-10} m
 (b) -1.5 eV, This is the n = 3 energy level.

17. 486 nm

18. **(a)** 6.9×10^{14} Hz **(b)** 4.4×10^{-7} m
 (c) -0.54 **(d)** 1.3×10^{-9} m
 (e) 9.5×10^{-8} m

Unit 7 Review

Problems for Understanding

26. **(a)** $0.14c$ **(b)** $0.045c$

27. **(a)** 9×10^{16} J **(b)** 3×10^7 a

28. **(a)** 3.1 light-year **(b)** 4.7 a
 (c) 6.3 a

29. **(a)** 1.1×10^{-13} J
 (b) 1.3 × rest mass energy
 (c) 2.1×10^{-30} kg or 2.3 × rest mass

30. **(a)** 3×10^9 J **(b)** 4×10^{-8} kg

31. 1.12 eV = 1.80×10^{-19} J

32. 4.7 eV = 7.5×10^{-19} J

33. **(a)** 1.05×10^{15} Hz
 (b) 287 nm

34. **(a)** 1.25 nm **(b)** 0.153 nm

35. **(a)** 2.47×10^{15} Hz
 (b) 1.22×10^{-7} m
 (c) Lyman

36. 486 nm

37. **(a)** 3.0×10^{-19} J
 (b) 8.1×10^{17} photons

38. **(a)** 6.91×10^{14} Hz
 (b) 4.34×10^{-7} m
 (c) -0.544 eV = -8.70×10^{-20} J
 (d) 1.32 nm
 (e) 9.49×10^{-8} m
 (f) UV

Chapter 20

Practice Problems

1. 0.06066 u = 1.0073×10^{-28} kg
2. 1.237×10^{-11} J
3. 2.858×10^{-10} J
4. 2.6×10^9 a
5. 3.5×10^3 a
6. 8.49×10^{-8} mg

Chapter 20 Review

Problems for Understanding

12. **(a)** 20 p, 20 n, 18 e
(b) 26 p, 30 n, 26 e
(c) 17 p, 18 n, 18 e

13. **(a)** 1.4765×10^{-11} J
(b) 1.7927×10^{-10} J

14. ${}^{230}_{90}\text{Th} \rightarrow {}^{4}_{2}\text{He} + {}^{226}_{88}\text{Ra}$

15. **(a)** 1/4 **(b)** 1/16
(c) 1/4096

16. **(a)** 4.876 MeV
(b) $v_{He} = 1.520 \times 10^{7}$ m/s;
$v_{Rn} = 2.740 \times 10^{5}$ m/s
(c) 98.1%

17. 1.19×10^{-7} g

18. 43 min

19. 1.2×10^{4} a

20. **(a)** 200 **(b)** 600
(c) 25 **(d)** 775
(e) ${}^{D}N = {}^{P}N_0\left(1 - \left(\frac{1}{2}\right)^{\frac{\Delta t}{T_{\frac{1}{2}}}}\right)$, where ${}^{D}N$ is the number of daughter nuclei at any time t, ${}^{P}N_0$ is the number of parent nuclei at time $t = 0$, and $T_{\frac{1}{2}}$ is the half-life of the parent nucleus.

21. **(a)** $\frac{N_U}{N_{Pb}} = \frac{\left(\frac{1}{2}\right)^{\frac{\Delta t}{T_{\frac{1}{2}}}}}{1 - \left(\frac{1}{2}\right)^{\frac{\Delta t}{T_{\frac{1}{2}}}}}$
(b) 4.26×10^{9} a; 3.89×10^{9} a; 2.93×10^{9} a
(c) Since the ratios and therefore the ages differ, the rocks must not have solidified at the same time.
(d) More than one half-life has elapsed.

Chapter 21

Practice Problems

1. 0.14168 u = 2.3527×10^{-28} kg; 2.114×10^{-11} J

2. 2.818×10^{-12} J

3. **(a)** 0.0265 u = 4.40×10^{-29} kg; 3.96×10^{-12} J
(b) 5.96×10^{11} J

Chapter 21 Review

Problems for Understanding

20. 8.194×10^{-14} J

21. ${}^{1}_{0}\text{n} + {}^{235}_{92}\text{U} \rightarrow {}^{90}_{37}\text{Rb} + {}^{144}_{55}\text{Cs} + 2\,{}^{1}_{0}\text{n}$

Unit 8 Review

26. **(a)** 3.96×10^{-12} J/reaction
(b) 9.68×10^{37} reactions/s
(c) 6.64×10^{-27} kg/reaction
(d) 6.43×10^{11} kg/s
(e) 9.82×10^{9} a

27. **(a)** 4.40×10^{-29} kg
(b) 0.6580%
(c) 1.18×10^{45} J
(d) 9.59×10^{9} a

28. 88.2 N

29. 5.9 days

30. 9.580×10^{-13} J