

ACTIVITY BASED PHYSICS

MECHANICS PRACTICE PROBLEM SETS



SOUTHINGTON HIGH SCHOOL
CCP PHYSICS

MECHANICS PRACTICE PROBLEM SET

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Unit 2 KINEMATICS**2.1 ONE DIMENSIONAL MOTION**

1. A car moving at 10 m/s speeds up uniformly to a speed of 30 m/s in a time of 5 seconds. What was the car's acceleration?
Answer: 4 m/s²
2. A bus is moving at a speed of 20 m/s, when it begins to slow at a constant rate of 5 m/s² in order to stop at a bus stop. If it comes to rest at the bus stop, how far away was the bus from the stop?
Answer: 40 m
3. A block starting from rest slides down the length of an 18 m plank with a uniform acceleration of 4.0 m/s². How long does the block take to reach the bottom?
Answer: 3.0 sec
4. An airplane initially flying at a speed of 60.0 m/s accelerates at 5.0 m/s² for 600 meters. What is its velocity after this acceleration?
Answer: 98 m/s
5. A biker passes a lamppost at the crest of a hill at +4.5 m/s. She accelerates down the hill at a constant rate of +0.40 m/s² for 12 s. How far does she move down the hill during this time?
Answer: 83 m
6. A pilot stops a plane in 484 m using a constant acceleration of -8.0 m/s². How fast was the plane moving before braking began?
Answer: 88 m/s
7. Wile E. Coyote has strapped himself to an ACME rocket and is moving along at 25.0 m/s in pursuit of the roadrunner. As he is cruising along he realizes that he is heading directly for the edge of a cliff. He drags his feet in order to slow down at a constant rate of 5.86 m/s² until he comes to rest. If the cliff is 36.0 meters away, by how much does he overshoot the edge?
Answer: 17.3 m
8. A rocket traveling at 88 m/s is accelerated to 132 m/s over a 15 second interval. What is its displacement in this time?
Answer: 1650 m
9. A car sits in an entrance ramp to a freeway, waiting for a break in traffic. The driver sees a small gap between two vehicles and accelerates with constant acceleration along the ramp onto the freeway. The car starts from rest, moves in a straight line, and has a speed of 20 m/s when it reaches the end of the 120-m ramp. What is the acceleration of the car?
Answer: 1.7 m/s²
 - a. How much time does it take the car to reach the end of the ramp?
Answer: 12 s
 - b. The traffic on the freeway is moving at a constant speed of 20 m/s. What distance does traffic travel while the car is moving the length of the ramp?
Answer: 240 m

10. An object starts from rest and accelerates uniformly at 5 m/s^2 for 3 seconds, then continues at a constant speed for 2s and finally accelerates uniformly at 2 m/s^2 for 3 seconds.
- Make a graph of the displacement vs. time **and** the velocity vs. time.
 - Find the final speed of the object. **Answer: 21 m/s**
 - Find the total distance traveled during this 8-second interval. **Answer: 107 m**
11. (G3) If you are driving 110 km/hr along a straight road and you look to the side for 2.0 seconds, how far do you travel during this inattentive period? **Answer: 61 m**
12. (G5) You are driving home from school steadily at 65 mph for 130 minutes. It then begins to rain and you slow to 55 mph. You arrive home after driving 3 hours and 20 minutes. How far is your hometown from school? **Answer: 203 mi**
- What was your average speed? **Answer: 61 mph**
13. (G7) A person jogs eight complete laps around a quarter-mile track in a total time of 12.5 minutes. What is the person's average speed? **Answer: 4.29 m/s**
- What is the person's average velocity? **Answer: 0 m/s**
14. (G13) A sports car accelerates from rest to 95 km/hr in 6.2 seconds. What is its average acceleration in m/s^2 ? **Answer: 4.3 m/s^2**
15. (G15) A sprinter accelerates from rest to 10.0 m/s in 1.35 s. What is her acceleration in m/s^2 ? **Answer: 7.41 m/s^2**
16. (G19) A car accelerates from 12 m/s to 25 m/s in 6.0 sec. Assume constant acceleration.
- What was its acceleration? **Answer: 2.2 m/s^2**
 - How far did it travel in this time? **Answer: 1.1 $\times 10^2 \text{ m}$**
17. (G21) A light plane must reach a speed of 30 m/s for takeoff. How long a runway is needed if the constant acceleration is 3.0 m/s^2 ? **Answer: 1.5 $\times 10^2 \text{ m}$**
18. (G23) A car slows down from a speed of 25.0 m/s to rest in 5.00 sec. How far did it travel in this time? **Answer: 62.5 m**
19. (G25) A car traveling 45 km/hr slows down at a constant 0.50 m/s^2 just by "letting up on the gas." Calculate:
- The distance the car coasts before it stops. **Answer: 1.6 $\times 10^2 \text{ m}$**
 - The time it takes to stop. **Answer: 25 s**

20. (G27) Determine the stopping distance for an automobile with an initial speed of 90 km/hr and human reaction time of 1.0 sec for an acceleration of -4.0 m/s^2 .
Answer: 103 m
- g. Repeat this process for an acceleration of -8.0 m/s^2 . *Answer: 64 m*
21. (G29) A speeding motorist traveling 120 km/hr passes a stationary police officer. The officer immediately begins pursuit at a constant acceleration of 2.78 m/s^2 . How much time will it take for the police officer to reach the speeder, assuming that the speeder maintains a constant speed? *Answer: 24.0 s*
- h. How fast will the police officer be traveling at this time?
Answer: 240 km/hr

2.2 FREEFALL

Answer the following questions on a separate piece of paper. In all problems, ignore the effects of air resistance and use $g = 9.8 \text{ m/s}^2$.

1. The "Free Fall Machine" at a local amusement park is freely falling for 1.5 s.
 - a. What is its velocity at the end of this time? *Answer: 14.7 m/s*
 - b. How far does it fall? *Answer: 11.0 m*
2. A man falls 1.0 m to the floor. How long does the fall take?
Answer: 0.45 sec
3. A student drops a rock from a bridge to the water 12.0 m below. With what speed does the rock strike the water?
Answer: 15.3 m/s
4. A flea can jump straight up to a height of 0.440 m. What is its initial speed when it leaves the ground?
Answer: 2.94 m/s
 - a. For how much time is it in the air? *Answer: 0.599 sec*
5. Jillian angrily throws her engagement ring straight up from the roof of a building that is 12.0 m above the ground with an initial speed of 5.00 m/s. Air resistance can be ignored. For the motion from her hand to the ground, determine:
 - a. The time it takes for the ring to strike the ground.
Answer: 2.16 sec
 - b. The speed the ring has just before it strikes the ground.
Answer: 16.1 m/s
 - c. Sketch a $y-t$, $v-t$, and $a-t$ graph for the motion of the ring.
6. A student throws a water balloon vertically downward from the top of a building. The balloon leaves the thrower's hand with a speed of 6.00 m/s. Air resistance may be ignored, so the water balloon is in free fall after it leaves the thrower's hand.
 - a. What is the speed after falling 2.00 s? *Answer: 25.6 m/s*
 - b. How far does it fall in 2.00 s? *Answer: 31.6 m*
 - c. What is the magnitude of its velocity after falling 10.0 m?
Answer: 15.2 m/s

7. You shoot an arrow straight upward at an initial speed of 30.0 m/s. How high will it fly?
Answer: 45.9 m
8. Your friend holds a ruler. You place your fingers at its bottom without touching it. She drops the ruler without warning. You catch the ruler after it falls 12.0 cm. What was your reaction time?
Answer: 0.16 sec
9. Do you recall Galileo's famous experiment where he dropped a light rock and a heavy rock from the Leaning Tower of Pisa (it may not actually have happened but it's still famous)? The tower is 55 m high. Suppose that Galileo accidentally dropped one rock 0.50 s before the second rock. With what initial velocity should he drop the second rock to that it reaches the ground at the same time as the first rock?
Answer: 5.3 m/s
10. A physics book slides off a horizontal table top with a speed of 1.10 m/s. It strikes the floor in 0.350 s. Find:
- The height of the table above the floor. *Answer: 0.600 m*
 - The horizontal distance from the edge of the table to the point where the book strikes the floor. *Answer: 0.385 m*
11. A stone is thrown horizontally at 15 m/s from the top of a cliff 44 meters high. How far from the base does the stone hit the ground? *Answer: 45 m*
12. A steel ball rolls with constant velocity across a tabletop 0.950 m high. It rolls off and hits the ground 0.352 meters from the edge of the table. How fast was the ball rolling when it left the table?
Answer: 0.800 m/s
13. A ball is launched with an initial velocity of 4.47 m/s at an angle of 66° above the horizontal.
- The maximum height the ball attained. *Answer: 0.849 m*
 - The time required to return to the launching height? *Answer: 0.833 sec*
 - The distance it landed. *Answer: 1.52 m*
14. A pistol that fires a signal flare gives the flare an initial speed of 120 m/s. If the flare is fired at an angle of 55° above the horizontal on the level salt flats of Utah, how far away will it land?
Answer: 2.4×10^3 m
- If the flare is fired on the moon, where $g = 1.6 \text{ m/s}^2$, how far away will it land?
Answer: 1.5×10^4 m
15. A rocket is fired at a speed of 75.0 m/s from ground level, at an angle of 60.0° above the horizontal. The rocket is fired toward an 11.0 m high wall,

which is located 27.0 meters away. The rocket attains its launch speed in a negligibly short period of time, after which its engines shut down and the rocket coasts. By how much does the rocket clear the top of the wall?

Answer: 33.2 m

16. (G35) Calculate the time it took for King Kong to fall straight down from the top of the Empire State Building (380 m high)? *Answer: 8.81 sec*

a. What is his velocity just before landing? *Answer: 86.3 m/s*

17. (GE2.13) A person throws a ball *upward* into the air with an initial velocity of 15.0 m/s. Only looking at the motion of the ball *after* it leaves the thrower's hand, calculate:

a. How high the ball goes? *Answer: 11.5 m*

b. How long it is in the air before it returns to his hand? *Answer: 3.06 s*

18. (G37) A kangaroo jumps to a vertical height of 2.7 m. How long was it in the air before returning to Earth? *Answer: 1.5 sec*

19. (G41) A helicopter is ascending vertically with a speed of 5.50 m/s. At a height of 105 m above the Earth, a package is dropped from a window. How much time does it take for the package to reach the ground?

Answer: 5.22 sec

20. (G47) A rock is dropped from a sea cliff and the sound of it striking the ocean is heard 3.4 sec later. If the speed of sound is 340 m/s, how high is the cliff?

Answer: 52 m

2.3 KINEMATICS TEST REVIEW PROBLEMS

2.3.1 Kinematics and Freefall

1. An object with an initial velocity of 47.0 m/s accelerates uniformly at 2.0 m/s^2 for 9.0 s. Calculate the displacement of the object after 9.0 s. *Answer: 504 m*
2. A driver of a car going 25 m/s suddenly sees the lights of a barrier 40.0 m ahead. It takes the driver 0.75 s before he applies the brakes, and the average acceleration during braking is -10.0 m/s^2 . Does the car hit the barrier? *Answer: Yes, $x = 50 \text{ m}$*
3. Highway safety engineers build soft barriers so that cars hitting them will slow down at a safe rate. A person wearing a safety belt can withstand an acceleration of -300 m/s^2 . How thick should barriers be to safely stop a car that hits a barrier at 30.56 m/s? *Answer: $x = 1.6 \text{ m}$*
4. A weather balloon is floating at a constant height above Earth when it releases a pack of instruments.
 - a. If the pack hits the ground with a velocity of 73.5 m/s, how far does the pack fall? *Answer: $y = 276 \text{ m down}$*
 - b. How long does the pack fall? *Answer: $t = 7.5 \text{ sec}$*
5. Kyle is flying a helicopter that is rising at 5.0 m/s when he releases a bag of tools. After 2.0 s...
 - a. What is the bag's velocity? *Answer: $v_f = -14.6 \text{ m/s}$*
 - b. How far has the bag fallen? *Answer: $y = -9.6 \text{ m}$*
 - c. How far below the helicopter is the bag? *Answer: 19.6 m apart*

2.3.2 Projectile Motion

6. An auto, moving too fast on a horizontal stretch of mountain road, slides off the road, falling into deep snow 43.9m below the road and 87.7 m beyond the edge of the road.
 - a. How long did the auto take to fall? *Answer: 2.99 sec*
 - b. How fast was it going when it left the road? *Answer: 29.3 m/s*
7. A player kicks a football from ground level with a velocity of magnitude 27 m/s at an angle of 30 degrees above the horizontal. Find:
 - c. The time it is in the air. *Answer: $t = 2.8 \text{ s}$*
 - d. The maximum height it reaches. *Answer: $y = 9.3 \text{ m}$*
 - e. Its distance from the player when it lands. *Answer: $x = 66 \text{ m}$*
8. Jane jumps off a high-diving platform with a horizontal velocity of 2.8 m/s and lands in the water 2.6 s later. How high is the platform, and how far from the base of the platform does she land? *Answer: $y = 33 \text{ m}, x = 7.3 \text{ m}$*
9. A bullet is shot at an angle of 15 degrees with an initial velocity of 200. m/s. Find:

- f. How long is it in the air. *Answer: $t = 10.6\text{ s}$*
- g. The maximum height it reaches. *Answer: $y = 137\text{ m}$*
- h. How far from the player does it land? *Answer: $x = 2050\text{ m}$*
10. (G19) A tiger leaps horizontally from a 7.5 m high rock with a speed of 4.5 m/s. How far from the base of the rock will she land? *Answer: 5.6 m*
11. (G27) A ball thrown horizontally at 22.2 m/s from the roof of a building lands 36.0 m from the base of the building. How high is the building? *Answer: 12.9 m*
12. (G31) A pilot of an airplane traveling 160 km/hr wants to drop supplies to flood victims isolated on a patch of land 160 m below. The supplies should be dropped how many seconds before the plane is directly overhead? *Answer: 5.71 sec*
13. (G35) A projectile is fired with an initial speed of 75.2 m/s at an angle of 34.5° above the horizontal on a long flat firing range. Determine:
- a. The maximum height reached by the projectile. *Answer: 92.6 m*
- b. The total time in the air. *Answer: 8.69 sec*
- c. The total horizontal distance covered. *Answer: 539 m*
- d. The velocity of the projectile 1.50 sec after firing. *Answer: $68.0\text{ m/s}, 24.2^\circ$*

Unit 3 DYNAMICS**3.1 NEWTON'S FIRST AND SECOND LAWS**

1. If a net horizontal force of 132 N is applied to a person with a mass of 60 kg who is resting on the edge of a swimming pool, what horizontal and vertical acceleration is produced?
*Answer: $a_x = 2.2 \text{ m/s}^2$
 $a_y = 0 \text{ m/s}^2$*
2. A 61.0 kg object is to be given a horizontal acceleration of $+0.70 \text{ m/s}^2$. How large an unbalanced force must act upon it? *Answer: 43 N*
3. A child pulls a wagon with a force of 77 N by a handle making an angle of 10° with the horizontal. If the wagon has a mass of 4.2 kg and we ignore friction, what is the horizontal acceleration of the wagon?
Answer: 18 m/s²
4. A towrope will break if the tension in it exceeds 1500 N. It is used to tow a 700 kg car along level ground. What is the maximum acceleration of the car if the wind resistance results in an opposing force of 25 N?
Answer: 2.1 m/s²
 - a. If the car is going to be towed onto the highway, it needs to reach a speed of 30 km/hr. How long will it take to get to this speed?
Answer: 4.0 sec
 - b. How much distance is covered in this time?
Answer: 17 m
5. What average force is needed to accelerate a 7.00-gram pellet from rest to 175 m/s over a distance of 0.700 m along the barrel of a rifle?
Answer: 153 N
6. A box rests on a frozen pond, which serves as a frictionless horizontal surface. A fisherman applies a horizontal force with a magnitude of 48.0 N at an angle of 30° to the horizontal produces an acceleration of 3.00 m/s^2 , what is the mass of the box?
Answer: 13.9 kg
7. Both Suzy and Maria both want to pull their little sister, Michelle, on a sled. Suzy grabs hold of the rope attached to the front of the sled and pulls on it with a force of 25.0 N at an angle of 45° . Maria grabs hold of the rope on the back of the sled and pulls in the opposite direction with a force of 21.0 N also at an angle. The total mass of the sled and Michelle is 70 kg. At what angle must Maria pull if the sled is to remain stationary?
Answer: 33°
 - a. At what angle must she pull if Michelle is to move at a constant velocity of 5 m/s to the right?
 - b. At what angle must she pull if Michelle is to move at a constant velocity of 2 m/s to the left?

8. An advertisement claims that their car can “stop on a dime.” What net force would actually be necessary to stop an 850-kg automobile traveling initially at 45.0 km/hr in a distance that is equal to the diameter of a dime, which is 1.8 cm?

Answer: $3.7 \times 10^6 \text{ N}$

9. An 875-kg car starts from rest and attains a speed of 26.3 m/s in 0.59 seconds. What is the magnitude of the average net force on the dragster during this time?

Answer: $3.9 \times 10^4 \text{ N}$

- a. Assuming the driver has a mass of 68 kg, how many times larger is the force on the car than the horizontal force exerted on the driver by the seat?

Answer: 13x

3.2 TENSION, FRICTION & VECTORS

1. A cord supports an object with a mass of 10 kg. Find the tension in the cord if the object is:
 - a. At rest. *Answer: $T = 98\text{ N}$*
 - b. Moving at constant velocity upward. *Answer: $T = 98\text{ N}$*
 - c. Moving at constant velocity downward. *Answer: $T = 98\text{ N}$*
 - d. Accelerating upward with at $a = 4.7\text{ m/s}^2$. *Answer: $T = 145\text{ N}$*
 - e. Accelerating downward with at $a = 2.4\text{ m/s}^2$. *Answer: $T = 74\text{ N}$*
2. An object with a weight of 600 N is given a horizontal acceleration of 0.70 m/s^2 . How large an unbalanced force must act upon it? *Answer: $F_{net} = 43\text{ N}$*
3. A $2.0 \times 10^{-4}\text{ kg}$ spider is suspended from a thin strand of spider web. The greatest tension the strand can withstand without breaking is $2.0 \times 10^{-3}\text{ N}$. What is the maximum acceleration with which the spider can safely ascend the strand?
Answer: $a = 0.20\text{ m/s}^2$
4. When a 0.40 kg apple is dropped, the earth exerts a force on it, giving it an acceleration of 9.8 m/s^2 . If the Earth's mass is $5.98 \times 10^{24}\text{ kg}$, what is the Earth's acceleration?
Answer: $a = 6.6 \times 10^{-25}\text{ m/s}^2$
5. A 20 kg block of wood is at rest on an ice-covered lake. You attach a rope to it and pull on it with a constant force at an angle of 30° . After 3.5 seconds it has a speed of 5 m/s . Ignoring friction, with what magnitude of the force you pulled on the block?
Answer: $F = 32\text{ N}$
 - a. What is the magnitude of the normal force on the box by the ground?
Answer: $F = 180\text{ N}$
6. A waitress shoves a ketchup bottle with a mass 0.45 kg toward the right along a smooth, level lunch counter. As the bottle leaves her hand, it has an initial velocity of 2.8 m/s . As it slides, it slows down because of the constant horizontal friction force exerted on it by the countertop. It slides a distance of 1.0 m before coming to rest. What are the magnitude and direction of the friction force?
Answer: -1.76 N
7. If you use a horizontal force of 30.0 N to slide a 12.0 kg wooden crate across a floor at a constant velocity, what is the coefficient of kinetic friction between the crate and the floor?
Answer: $\mu_k = 0.26$
8. Suppose a delivery company has just unloaded a 51 kg crate full of home exercise equipment on the sidewalk in front of your house. To get it into your house, you tie a rope to it and pull horizontally with a constant force of 125 N . If the crate accelerates at 0.5 m/s^2 , what is the coefficient of friction between the crate and the sidewalk?
Answer: $\mu = 0.20$

9. A cart is released at the top of an inclined plane that is elevated 20.0° from the horizontal. The cart has a mass of 1.12 kg and reaches a velocity of 1.2 m/s after 3.0 seconds. What is the coefficient of kinetic friction between the incline and the block?
Answer: $\mu = 0.32$

10. Add the following vectors both *graphically* and *analytically*. Your answer for each method must include the both the magnitude and the angle.

$$A = 2.5 \text{ cm at } 40^\circ$$

$$B = 6.0 \text{ cm at } 150^\circ$$

Answer: $R = 5.7 \text{ cm at } 125^\circ$

3.3 DYNAMICS REVIEW PROBLEMS

1. A large motorcycle weighs 2450 N. Calculate its mass in kilograms.
Answer: $m = 250 \text{ kg}$
2. A car with a mass of 700-kg changes its speed from 10.0 m/s to 30.0 m/s in a displacement of 50.0 meters. Calculate the net force acting on the car during this time.
Answer: $F_{net} = 5600 \text{ N}$
3. A 5.0 kg object is to be given an upward acceleration of 0.30 m/s^2 by pulling on a rope straight upward. What must be the tension in the rope?
Answer: $T = 51 \text{ N}$
4. A horizontal force of 50 N is required to slide a 15 kg steel crate across the floor at a constant velocity. What is the coefficient of sliding friction between the crate and the floor?
Answer: $\mu = 0.34$
5. Lucy is a 45.90 kg girl that is sitting on a tire swing. Schroeder pulls back horizontally on the swing. This causes the rope of tire swing to make a 30° angle with the horizontal. With what force must Schroeder pull back with and what is the tension in the rope to keep Lucy at rest?
Answer: $T = 899.6 \text{ N}, F_{LS} = 779.1 \text{ N}$
6. A 0.30 kg mass hangs at the end of a string. A second string hangs from the bottom of this mass and supports a 0.90 kg mass. Find the tension in each string when the masses are accelerating upward at 0.70 m/s^2 . Ignore air resistance.
Answer: $T_1 = 13 \text{ N}, T_2 = 9.5 \text{ N}$
7. A small block with a mass of 300 grams and a large block with a mass of 500 grams are pushed by a force F as shown below. The blocks accelerate together with an acceleration of 200 cm/s^2 . The frictional forces are 1.2 N on the small block and 2.0 N on the large block. **Watch your units!!**
 - a. How large a force does the 300-gram block exert on the 500-gram block during this motion.
Answer: $F_{LS} = 3.0 \text{ N}$
 - b. What must be the value of F_{SP} be to get this acceleration?
Answer: $F = 4.8 \text{ N}$



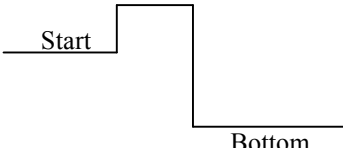
8. (G5) What is the weight of a 66-kg astronaut on Earth? *Answer: $6.5 \times 10^2 \text{ N}$*
 - a. On the moon ($g=1.6 \text{ m/s}^2$)? *Answer: $1.1 \times 10^2 \text{ N}$*

- b. On Mars ($g=3.7 \text{ m/s}^2$)? *Answer: $2.4 \times 10^2 \text{ N}$*
- c. In outer space traveling at constant velocity? *Answer: 0 N*
9. (G7) What average force is required to stop an 1100-kg car in 8.0 seconds if it is traveling at 90 km/hr? *Answer: $3.4 \times 10^3 \text{ N opposite direction}$*
10. (G11) What is the average force exerted by a shot-putter on a 7.0 kg shot if the shot is moved through a distance of 2.8 m and is released with a speed of 1.3 m/s? *Answer: $2.1 \times 10^2 \text{ N}$*
11. (G13) A 10-kg bucket is lowered by a rope in which there is 63 N of tension. What is the acceleration of the bucket? Is it up or down? *Answer: $3.5 \text{ m/s}^2 \text{ down}$*
12. (G17) The cable supporting a 2100-kg elevator has a maximum strength of 21,750 N. What maximum upward acceleration can it give the elevator without breaking? *Answer: 0.557 m/s^2*
13. (G19) A Saturn V rocket has a mass of $2.75 \times 10^6 \text{ kg}$ and exerts a force of $33 \times 10^6 \text{ N}$ on the gases it expels. Ignoring the mass of the gases expelled and assuming that g remains constant, determine:
- The initial vertical acceleration of the rocket. *Answer: 2.2 m/s^2*
 - Its velocity after 8.0 sec. *Answer: 18 m/s*
 - How long it takes to reach an altitude of 9500 m. *Answer: 93 sec*
14. (G39) A ball thrown horizontally at 22.2 m/s from the roof of a building lands 36.0 m from the base of the building. How high is the building? *Answer: $\mu_s = 0.82, \mu_k = 0.74$*
15. (G41) A pilot of an airplane traveling 160 km/hr wants to drop supplies to flood victims isolated on a patch of land 160 m below. The supplies should be dropped how many seconds before the plane is directly overhead? *Answer: $\mu_s = 0.82$*
16. (G43) A pilot of an airplane traveling 160 km/hr wants to drop supplies to flood victims isolated on a patch of land 160 m below. The supplies should be dropped how many seconds before the plane is directly overhead? *Answer: 5.71 sec*
17. G45) A pilot of an airplane traveling 160 km/hr wants to drop supplies to flood victims isolated on a patch of land 160 m below. The supplies should be dropped how many seconds before the plane is directly overhead? *Answer: 5.71 sec*
18. (G47) A projectile is fired with an initial speed of 75.2 m/s at an angle of 34.5° above the horizontal on a long flat firing range. Determine:
- The maximum height reached by the projectile. *Answer: 92.6 m*

- b. The total time in the air. *Answer: 8.69 sec*
- c. The total horizontal distance covered. *Answer: 539 m*
- d. The velocity of the projectile 1.50 sec after firing. *Answer: 68.0 m/s, 24.2°*

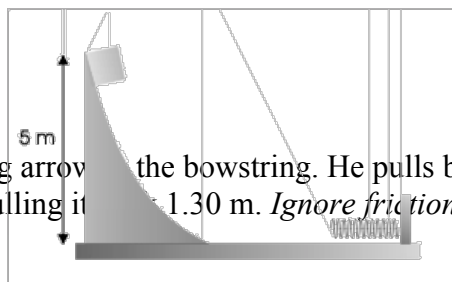
Unit 4 WORK AND ENERGY**4.1 WORK, KINETIC ENERGY AND POTENTIAL ENERGY**

1. A rope is used to pull 255 N on a boat along side a pier. If the rope is held at a constant 60° angle, with the horizontal, and the sailor pulls the boat 30 m, how much work is done by the sailor?
Answer: 3825 J
2. The dinosaur *Tyrannosaurus rex* is thought to have had a mass of about 7000 kg.
 - a. How much kinetic energy would it have if its walking speed were about 4.0 km/hr?
Answer: 4320 J
 - b. How fast would a 70.0 kg person have to walk to have the same kinetic energy as the walking *T. rex*?
Answer: 11.1 m/s
3. How large a force is required to accelerate a 1300 kg car from rest to a speed of 20 m/s in a distance of 80 m?
Answer: 3250 N
4. An 875-kg compact car is driving at 44.0 m/s when he sees a police car up ahead. Trying to avoid another speeding ticket, the driver slows down to 22.0 m/s.
 - a. If it takes 250 meters to slow the car down, what is the average breaking force on the car?
Answer: -2540 N
 - b. The police officer caught the driver with his radar gun and decides to pull him over. Assuming the same breaking force from part a, how much distance will the driver require slow down from 22.0 m/s to rest?
Answer: 83.4 m
5. A 0.50 kg block slides across a tabletop with an initial velocity of 20 cm/s and comes to rest in a distance of 0.70 m.
 - a. Find the average friction force acting on the block.
Answer: -1.4 N
 - b. Find the coefficient of friction between the block and the tabletop.
Answer: 0.29
6. A 12-pack of cola with a mass of 4.30 kg is initially at rest on a horizontal floor. It is then pushed in a straight line for 1.2 m by a horizontal force of 36.0 N. What is the final speed of the 12-pack if...
 - a. There is no friction between the 12-pack and the floor?
Answer: 4.5 m/s
 - b. The coefficient of kinetic friction between the 12-pack and the floor is 0.30.
Answer: 3.6 m/s
7. A comet with a mass of 7.85×10^{11} kg strikes Earth at a speed of 25.0 km/s.
 - a. How much kinetic energy does the comet have? *Answer: 2.45×10^{20} J*
 - b. How much work is done to stop the comet? *Answer: -2.45×10^{20} J*
 - c. How many times larger (or smaller) is the work done than the energy released by the largest nuclear weapon ever built with an energy release of 4.2×10^{15} J?
Answer: 58,000x

8. A 66 kg rock climber first climbs 45 m upward to the top edge of a quarry. Then he descends 85 m to the bottom of the quarry. Using the initial height as a reference, find the potential energy of the rock climber at...
- 
- a. The top of the quarry. *Answer: 29,100 J*
- b. The bottom of the quarry. *Answer: -25,900 J*
9. A spring of negligible mass has a spring constant (K) of 1600 N/m.
- a. How much potential energy (PE) will be stored at equilibrium?
Answer: 0 J
- b. How much PE will be stored if it is extended 0.15 meters away from equilibrium?
Answer: 18.0 J
- c. How far must the spring be compressed to store 3.20 J of potential energy?
Answer: 0.06 m

4.2 WORK, CONSERVATION OF ENERGY AND POWER

- How much work does an 825 N force that pushes a car 35 meters do?
Answer: 28,900 J
 - Would more, less, or the same amount of work be done if this 825 N force was applied at an angle of 45° ? *Use calculations to support your answer.*
Answer: 8500 J less
- A compact car of 875-kg is driving with a velocity of 20.0 m/s?
 - How much kinetic energy does it have? *Answer: 175,000 J*
 - What height above the ground would this car need to be lifted so that it had the same amount of gravitational potential energy?
Answer: 20.4 m
- With what force must an electric motor accelerate an elevator with a mass of 1200 from 1 m/s to 5 m/s over a distance of 9 m? *Answer: 1600 N*
- An engine moves a boat through the water at a constant speed of 15 m/s. The engine exerts a force of 6000 N to balance the force that the water exerts against the hull. What is the power of the engine in Watts and horsepower?
Answer: 90,000 W, 121 hp
- An electric motor develops 65,000 Watts of power as it lifts a loaded elevator 17 m in 35 seconds. How much force does the motor exert?
Answer: 1.3×10^5 N
- A penny with a mass of 2.5 grams is dropped from the top of the Empire State Building which has a height of 381 m. What is its velocity just as it reaches the ground?
Answer: 86.4 m/s
- A diver jumps off a diving board with an initial speed of 1.8 m/s. She enters the water with a velocity of 5.74 m/s. From what height above the water did she jump?
Answer: 1.52 m
- A small block of 0.10 kg is released from rest at a height of 5.0 meters as shown. The block slides down the frictionless surface and hits the spring, which is fixed against a wall. If the spring constant is 1000 N/m, how far will the spring be compressed when the block comes to a complete stop?
Answer: 9.9 cm
 - How much **more** will the spring compress if the block is given an initial velocity of 300 cm/s?
Answer: 0.44 cm

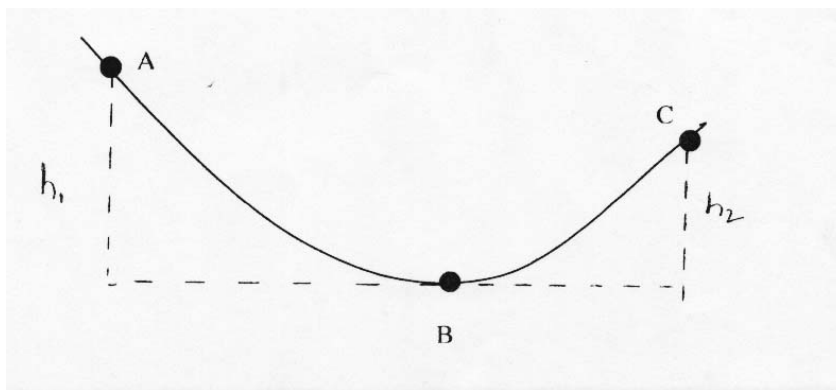


- An archer puts a 0.300 kg arrow in the bowstring. He pulls back on the bowstring with a force of 201 N, pulling it 1.30 m. *Ignore friction and air resistance!*

- a. What is the spring constant of the bowstring?
Answer: 155 N/m
- b. With what speed does the arrow leave the bow?
Answer: 29.5 m/s
- c. If the arrow is shot straight up, how high does it rise?
Answer: 44.5 m

4.3 WORK AND ENERGY REVIEW PROBLEMS

1. A person pushes a 20-kg mass 10 m across a floor with a horizontal force of 80 N. How much work is done? *Answer: 800 J*
 - a. How much work would be done if the force was applied at angle of 12° to the horizontal? *Answer: 780 J*
2. The escalator at Ocean Park in Hong Kong is the world's longest escalator with a length of 227 m with an inclination of 31° . If a person has a mass of 52 kg, what is the work done on the person by the escalator to bring them to the top? *Answer: 59,600 J*
3. A soccer ball of mass 0.420 kg is initially moving with speed 2.00 m/s. A soccer player kicks the ball, exerting a constant force of magnitude 40.0 N in the same direction at the ball's motion. Over what distance must her foot be in contact with the ball to increase the ball's speed to 6.00 m/s? *Answer: 0.168 m*
4. A tandem (two-person) bicycle team must overcome a force of 165 N to maintain a speed of 9.00 m/s. Find the power required by each rider in watts and horsepower. *Answer: 1490 W, 2.00 hp*
5. A large chunk of ice with a mass of 15.0 kg falls from a roof 8.00 meters above the ground. What is the speed of the ice when it reaches the ground? Ignore air resistance. *Answer: 12.5 m/s*
6. The figure below shows a bead sliding on a wire. How large must h_1 be if the bead starting from rest at A is to have a speed of 200. cm/s at point B? Ignore friction. *Answer: 20.4 cm*



7. Using the same figure below, we now state that $h_1 = 50$ cm, $h_2 = 30$ cm, and the length of the wire from A to C is 400 cm. A 3.0-gram bead is released at A, coasts to point C and stops. How large an average friction force opposed the motion of the bead? *Answer: 0.00147 N*
8. In a "worst-case" scenario, a 2000-kg elevator with broken cables is falling at 25 m/s when it first contacts a cushioning spring at the bottom of the elevator shaft. The

spring is supposed to stop the elevator, compressing 3.00 m as it does so. During the motion, an additional safety clamp applies a constant 17,000 N frictional force to the elevator. What should the spring constant be so that this mechanism works properly?

Answer: $1.41 \times 10^5 \text{ N}$

1. A 2.0 kg object is being pulled along the ground by a 7.5 N force directed 28° above the horizontal. How much work does the force do in pulling the object 8 m.
Answer: 53 J
 - a. If the coefficient of friction between the floor and the object is .20, how much work is done by friction? *Draw a FBD! Answer: 26 J*
2. A rifle can shoot a 0.0042 kg bullet at a speed of 965 m/s.
 - a. Find the kinetic energy of the bullet. *Answer: 1960 J*
 - b. What work is done on the bullet if it starts from rest? *Answer: 1960 J*
 - c. If the work is done over a distance of 0.75 m, what is the average force on the bullet? *Answer: 2600 N*
 - d. If the bullet comes to rest by pushing 1.5 cm into metal, what is the magnitude and direction of the average force on the bullet by the metal?
Answer: -130,00 N
3. A 15 kg cart is moving with a velocity of 7.50 m/s down a level hallway. A constant force of -10.0 N acts on the cart and its velocity becomes 3.20 m/s. How far did the cart move while the force acted? *Answer: 34.5 m*
4. Person A and Person B both have to carry a 3.5 kg package from the ground floor to the fifth floor of an office building, which is a total height of 15 m. Person B challenges Person A to race. Person B takes 15.0 seconds while Person A takes 20.0 seconds. Which person is more powerful and by how much?
Answer: Person A by 8.6 W
5. A 0.25 hp motor is used to lift a load at a rate of 5.0 cm/s. How great a load can it lift at this constant speed? *Answer: 3730 N*
6. From what height would a compact car have to be dropped to have the same kinetic energy that it has when being driven at 27.8 m/s? *Answer: 39.4 m*
7. A 98 N sack of grain is hoisted to a storage room 50 m above the ground floor. Then, the rope used to hoist the grain breaks just as it reaches the storage room. With what speed did it have when it struck the floor? *Answer: 31 m/s*
8. The Great Sandini is a 60-kg circus performer who is shot from a spring gun. The spring constant for this spring gun is 1100 N/m, and he will compress the spring with a force of 4400 N. The average friction force is only 40 N during the 4.0 m he moves in the barrel. If he emerges from the spring gun, 2.5 m above his initial rest position, how fast will he emerge from the barrel? *Answer: 15.5 m/s*

9. A block with mass 0.50 kg is forced against a horizontal spring of negligible mass, compressing the spring a distance of 0.20 m. When released, the block moves on a horizontal table top for 1.00 m before coming to rest. The spring constant k is 100 N/m. What is the coefficient of friction between the block and the table?
Answer: 0.41
10. (G1) A 75.0 kg firefighter climbs a flight of stairs 10.0 m high. How much work is required?
Answer: $7.35 \times 10^3 \text{ J}$
11. (G3) How much work did the movers do (horizontally) pushing a 150-kg crate 12.3 m across a rough floor without acceleration, if the effective coefficient of friction was 0.70?
Answer: $1.3 \times 10^4 \text{ J}$
12. (G9) Eight books, each 4.6 cm thick with a mass of 1.8 kg, lie flat on the table. How much work is required to stack them one on top of the other?
Answer: 23 J
13. (G19) How much work is required to stop an electron ($m = 9.11 \times 10^{-31} \text{ kg}$) that is moving at a speed of $1.90 \times 10^6 \text{ m/s}$?
Answer: $-1.64 \times 10^{-18} \text{ J}$
14. (G23) A baseball ($m=140 \text{ g}$) traveling 35 m/s moves a fielder's glove backward 25 cm when the ball is caught. What was the average force exerted by the ball on the glove?
*Answer: $3.4 \times 10^2 \text{ J}$
In direction of the ball*
15. (G29) A spring as a spring constant, k , of 440 n/m. How much must this spring be stretched to store 25 J of potential energy?
Answer: 0.34 m
16. (G33) A 55-kg hiker starts at an elevation of 1600 m and climbs to the top of a 3100-m peak.
- What is the hiker's change in potential energy? *Answer: $8.1 \times 10^5 \text{ J}$*
 - What is the minimum work required of the hiker?
Answer: $8.1 \times 10^5 \text{ J}$
 - Can the actual work done be more than this? Explain.
Answer: yes
17. (G35) Jane, looking for Tarzan, is running at top speed (5.6 m/s) and grabs a vine hanging vertically from a tall tree in the jungle. How high can she swing upward? Does the length of the vine affect your answer?
Answer: 1.6 m, no
18. (G39) A 75-kg trampoline artist jumps vertically upward from the top of a platform with a speed of 5.0 m/s.
- How fast is he going as he lands on the trampoline 3.0 m below?
Answer: 9.2 m/s
 - If the trampoline behaves like a spring with a spring constant of $5.2 \times 10^4 \text{ N/m}$, how far does he depress it?
Answer: 0.35 m

19. (G43) A vertical spring (ignore its mass) whose spring constant is 900 N/m is attached to a table and is compressed 0.150 m.
- What speed can it give to a 0.300-kg ball when released?
Answer: 8.03 m/s
 - How high above its **original** position (spring compressed) will the ball fly?
Answer: 3.44 m
20. (G51) A ski starts from rest and slides down a 20° incline 100 m long.
- If the coefficient of friction is 0.090, what is the ski's speed at the base of the incline?
Answer: 22 m/s
 - If the snow is level at the foot of the incline and has the same coefficient of friction, how far will the ski travel along the level ground? *Use energy methods!*
Answer: 2.9×10^2 m
21. (G55) A 0.520-kg block is firmly attached to a very light horizontal spring ($k = 180$ N/m). It is noted that the block-spring system, when compressed 5.0 cm and released, stretches out 2.3 cm beyond the equilibrium position before stopping and turning back. What is the coefficient of kinetic friction between the block and the table?
Answer: 0.48
22. (G65) A pump is to lift 8.00 kg of water per minute through a height of 3.50 m. What power rating should the pump motor have?
Answer: 4.57 W

Unit 5 IMPULSE, MOMENTUM & CONSERVATION OF MOMENTUM**5.1 IMPULSE AND MOMENTUM**

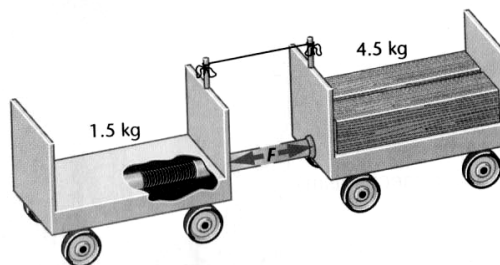
1. A compact car with a mass of 725 kg is moving at 90.0 km/hr toward the east.
 - a. Find the magnitude and direction of its momentum.
Answer: 18,125 kg•m/s east
 - b. A second car, with a mass of 2175 kg, has the same momentum. What is its velocity?
Answer: 8.3 m/s
2. The same compact car from question 1, suddenly applies the brakes hard for 2.0 s. As a result an average force of 5.0×10^3 N is exerted on the car to slow it.
 - a. What is the magnitude and direction of the impulse on the car?
Answer: -10,000 N•s
 - b. What is the magnitude and direction of the change in momentum of the car?
Answer: -10,000 kg•m/s
 - c. If the compact car was initially moving at 90 km/hr, what is its final velocity?
Answer: 11.2 m/s
3. A snowmobile with a mass of 24.0 kg accelerates from 6.00 m/s to 28.0 m/s in 1.00 min.
 - a. What is the snowmobile's change in momentum?
Answer: 528 kg•m/s
 - b. What is the magnitude and direction of the average force exerted on the snowmobile?
Answer: +8.8 N
4. A boy hits a 0.05 kg golf ball from rest to a speed of 75 m/s. What is the impulse given to the ball?
Answer: 3.75 N•s
 - a. If the impact lasted for 0.01 seconds, what was the average force of impact?
Answer: 375 N
5. A 0.144-kg baseball is pitched horizontally at 38.0 m/s. After the ball is hit by the bat, it moves in the opposite direction with a speed 42.0 m/s. If the bat and ball are in contact for 0.80×10^{-3} seconds, what was the average force the bat exerted on the ball?
Answer: -14,400 N
6. During an automobile crash test, a 1000 kg car is sent towards a cement wall at a speed of 14 m/s. It is brought to rest in 0.08 sec. What was the average force of the car on the wall?
Answer: +175,000 N
7. A bowling ball with a mass of 5.4 kg is moving at a velocity of 3 m/s. What is the bowling ball's momentum?
Answer: 16.2 kg•m/s
8. A 0.005 kg bullet is fired with a velocity of 100 m/s toward a 10 kg stationary solid block resting on a frictionless surface.
 - a. What is the change in momentum of the bullet if it is embedded in the block?
Answer: -0.5 kg•m/s

- b. What is the change in momentum of the bullet if it ricochets in the opposite direction with a speed of 99 m/s? *Answer: -0.995 kg•m/s*
9. A 10000 kg freight car is rolling along a track at 3 m/s. Calculate the time needed for a 1000 N force to stop it. *Answer: 30 sec*
10. A 0.160 kg hockey puck is moving to the right at 3.00 m/s. What is the velocity of the puck after a force directed to the right with a magnitude of 25.0 N is applied for 0.050 s? *Answer: 10.8 m/s*

5.2 CONSERVATION OF MOMENTUM

1. A 95-kg fullback running at 8.2 m/s collides in midair with a 128-kg defensive tackle moving in the opposite direction. After the collision, both players come to rest. How fast was the tackle moving initially? *Answer: -6.1 m/s*
2. A thread holds two carts together as shown in the diagram below. After the thread is cut, a compressed spring pushes the carts apart, giving the 1.5-kg car a speed of 27 cm/s to the left. What is the velocity of the 4.5-kg car?

Answer: 9.0 cm/s to the right



3. Two campers dock a canoe. Once the canoe comes to rest, one camper with a mass of 80.0-kg gets off the canoe with a velocity of +4.0 m/s. The canoe and the other camper drift off in the opposite direction with a speed of 2.78 m/s. What is the combined mass of the canoe and the second camper?
Answer: 115 kg
4. A spaceship with a mass of 2.0×10^6 kg is cruising at a speed of 5.0×10^6 m/s when it blows up into two pieces. One section, with a mass of 7.5×10^5 kg is blown straight backwards with a speed of 1.0×10^6 m/s. What is the magnitude and direction of the velocity of the second piece of the spaceship?
Answer: 8.6×10^6 m/s
5. A ceramic penguin with a mass of 0.5 kg suddenly bursts apart into two pieces. One piece has a mass of 0.15 kg and has a velocity of -2.0 m/s. What is the velocity of the second piece?
Answer: 0.86 m/s
6. The nucleus of an atom has a mass of 3.80×10^{-25} kg and is at rest. The nucleus is radioactive and suddenly ejects a particle of mass 6.60×10^{-27} kg at a speed of 1.50×10^7 m/s. Find the recoil speed of the nucleus that is left behind.
Answer: -2.65×10^5 m/s
7. A 0.2 kg plastic ball moves with a velocity of 0.3 m/s. It collides with a second plastic ball of mass 0.1 kg, moving along the same line at a velocity of 0.1 m/s. After the collision, the velocity of the 0.1 kg ball is 0.26 m/s. What is the new velocity of the first ball?
Answer: 0.22 m/s

8. A 40 kg girl is running along at 5.2 m/s and jumps into a 20 kg wagon. How fast will the wagon move with the girl in it? **Answer: 3.5 m/s**
9. A 0.12 kg bullet with a velocity of 400.0 m/s is shot into a ballistic pendulum with a mass of 6.00 kg and a string length of 70.0 cm. How fast will the pendulum and the embedded bullet be moving just after the collision?
Answer: 7.8 m/s
a. What is the vertical height the pendulum will reach at the top of its swing?
Answer: 3.10 m
10. A 620 kg moose stands in the middle of railroad tracks in Sweden, frozen by the lights of the oncoming train with 10,000 kg moving at 10 m/s. The conductor tries to slow the train down in time to avoid hitting the moose, but the moose ends up riding the remaining distance on the train's cowcatcher. What is the final velocity of the train and moose after the collision? **Answer: 9.4 m/s**
11. Two astronauts each with a mass of 75 kg are headed toward each other. The first astronaut has a velocity of +2.5 m/s while the other has a velocity of -1.5 m/s. In an attempt to stop each other, they collide and move together. What is their final velocity? **Answer: $v = +0.5$ m/s**
12. A 5.0 kg object moving to the right at 2.0m/s makes an elastic head-on collision with a 2.0 kg object moving in the opposite direction at 5.0m/s. Find the velocity of each object after the collision. **Answer: $v_{1f} = -2.0$ m/s , $v_{2f} = 5.0$ m/s**
13. A 0.012 kg bullet with an initial velocity of 275 m/s is fired horizontally into a 0.100 kg wood block that is initially at rest on a frictionless horizontal surface. The block is connected to a spring with $k = 150\text{N/m}$. When the bullet hits the block it embeds itself into it and the bullet-block system compresses the spring and comes to rest. How far does the spring compress?
Answer: $x = .81$ m
14. A 7.0g bullet is fired with an initial velocity of 528 m/s into a 1.5 kg ballistic pendulum. The bullet emerges from the block with a speed of 200m/s, and the pendulum swings upward. What is the maximum height of the pendulum?
Answer: $v_b = 528$ m/s
15. Your 0.030 kg shooter marble moving to the right at 0.200 m/s has a head on collision with an opponent's 0.010 kg marble, which is moving to the left at 0.400 m/s. If you are playing your game of marbles on an icy sidewalk so that friction can be ignored, what is the velocity of each marble after the collision?

Answer: $v_{1f} = -0.1 \text{ m/s}$, $v_{2f} = .5 \text{ m/s}$

16. An 8.00g bullet is fired into a 250g block that is initially at rest on the edge of a table that is 1m tall. The bullet remains in the block and after the collision the block lands 2.00m from the base of the table. What is the initial velocity of the bullet? *Hint: You will need to use projectile motion to solve this one!*

Answer: $v_b = 142.9 \text{ m/s}$

5.3 IMPULSE, MOMENTUM AND CONSERVATION REVIEW

1. A 237.5 kg motorcycle is moving at a speed of 112.5 m/s. What is the momentum of the motorcycle?
Answer: 26,720 kg•m/s
 - a. If this same motorcycle crashes into a wall and stops in a time of 0.05 seconds, how much force acted on the motorcycle?
Answer: -534,400 N
2. A small car with a mass of 300 kg is moving at 175 m/s. It crashes head on with a 950 kg truck moving at 100 m/s in the opposite direction. If the two cars become intertwined and mangled, with what velocity does the wreckage move?
Answer: 34 m/s in direction of the truck
3. Two children, totaling 200 kg, are traveling at 10 m/s in a 100 kg bumper car during an amusement park ride. They deliberately collide with an empty second car (mass of 100 kg), which is at rest. Afterwards, the car with the two children continues forward at a speed of 4.0 m/s. What is the final velocity of the empty car?
Answer: 18 m/s
4. An 80-kg man and his car are suddenly accelerated from rest to a speed of 5 m/s as a result of a rear-end collision. If the average force exerted on him by the back seat of the car is 1500 N, for how long did the collision occur?
Answer: 0.27 sec
5. On a hot summer day, Jack and Leon are fishing in their boat, which is at rest. After catching as much fish as they can, the two decide to jump off the boat. Jack, who is 45 kg, jumps off the front of the boat with a speed of 2 m/s. Leon, who is 90 kg, jumps out the back of the boat at a speed of 4 m/s. If the boat has a mass of 100 kg, what will be its velocity just after both boys have abandoned ship?
Answer: 2.7 m/s in the direction of Jack
6. To stop a running back from reaching the end zone, a defensive player exerts an average force of 550 N for a time of 0.50 seconds against his 110 kg opponent. If the running back enters the end zone with a velocity of 0.2 m/s, how fast was he initially running?
Answer: 2.7 m/s
7. (G14) A tennis ball may leave the racket of a top player on the serve with a speed of 65.0 m/s. If the ball's mass is 0.060 kg and it is in contact with the racket for 0.0300 s, what is the average force on the ball?
Answer: 130 N
 - a. Would this force be large enough to lift a 60-kg person?
Answer: No
8. (G15) A 0.145-kg baseball pitched at 39.0 m/s is hit on a horizontal line drive straight back toward the pitcher at 52.0 m/s. If the contact time between bat and ball is 1.00×10^{-3} s, calculate the average force between the ball and bat during contact.
Answer: 1.32×10^4 N

9. (G18) A 115-kg fullback is running at 4.0 m/s to the east and is stopped in 0.75 s by a head-on tackle by a tackler running due west. Calculate:
- The original momentum of the fullback. *Answer: 460 kg•m/s*
 - The impulse exerted on the fullback. *Answer: -460 kg•m/s*
 - The impulse exerted on the tackler. *Answer: 460 kg•m/s*
 - The average force exerted on the tackler. *Answer: 610 N*
10. (G5) A 12,500 kg railroad car travels alone on a level frictionless track with a constant speed of 18.0 m/s. A 5750-kg additional load is dropped onto the car. What then will be the car's speed?
Answer: 12.3 m/s
11. (G6) A 9500-kg boxcar traveling at 16 m/s strikes a second car. The two stick together and move off with a speed of 6.0 m/s. What is the mass of the second car?
Answer: 15,830 kg
12. (G7) A gun is fired vertically into a 1.40-kg block of wood at rest directly above. If the bullet has a mass of 21.0 g and a speed of 210 m/s, how high will the block of wood rise into the air after the bullet becomes embedded in it?
Answer: 0.491 m
13. (G11) A 13-g bullet traveling 230 m/s penetrates a 2.0 kg block of wood and emerges going 170 m/s. If the block is stationary on a frictionless surface when hit, how fast does it move after the bullet emerges? *Answer: 0.39 m/s*
14. (G21) A ball of mass 0.44 kg moving east with a speed of 3.70 m/s collides head-on with a 0.220-kg ball at rest. If the collision is perfectly elastic, what will be the speed and direction of each ball after the collision?
Answer: $v_{1f} = 1.23 \text{ m/s}$; $v_{2f} = 4.93 \text{ m/s}$
15. (G23) Two billiard balls of equal mass undergo a perfectly elastic head-on collision. If the speed of one ball was initially 2.00 m/s, and of the other 3.00 m/s in the opposite direction, what will their speeds be after the collision?
Answer: $v_{1f} = -3.00 \text{ m/s}$; $v_{2f} = 2.00 \text{ m/s}$
16. (G30) An 18-g rifle bullet traveling 230 m/s buries itself in a 3.6 kg pendulum hanging on a 2.8 m long string, which makes the pendulum swing upward in an arc. Determine the horizontal component of the pendulum's displacement.
Answer: 0.61 m
17. (G33) A 1.0×10^3 kg Toyota collides into the rear end of a 2.2×10^3 kg Cadillac stopped at a red light. The bumpers lock, the brakes are locked, and the two cars skid forward 2.8 m before stopping. The police officer, knowing that the coefficient of kinetic friction between tires and road is 0.40, calculates the speed of the Toyota at impact. What was that speed?

Answer: 15 m/s

- 18.(G62) A 5800-kg open railroad car coasts along with a constant speed of 8.60 m/s on a level track. Snow begins to fall vertically and fills the car at a rate of 3.50 kg/min. Ignoring friction with the tracks, what is the speed of the car after 90.0 min?

Answer: 8.16 m/s

- 19.(G66) A 140-kg astronaut (including space suit) acquires a speed of 2.50 m/s by pushing off with his legs from an 1800-kg space capsule. *As the reference frame, use the position of the capsule before the push.*

- a. What is the change in speed of the space capsule? *Answer: -0.194 m/s*
- b. If the push lasts 0.500 s, what is the average force exerted by each one the other? *Answer: 700 N*

Unit 6 UNIFORM CIRCULAR MOTION

6.1 UNIFORM CIRCULAR MOTION & GRAVITY

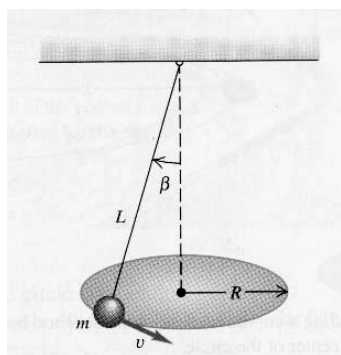
1. A mass of 1.5 kg moves in a circle with a radius of 0.25 m. It takes 0.5 seconds to complete one revolution.
 - a. What is the velocity of the mass? *Answer: 3.14 m/s*
 - b. What is the centripetal acceleration of the mass? *Answer: 39.4 m/s²*
 - c. What is the centripetal force on the mass? *Answer: 59.2 N*

2. The Cosmo-clock 21 Ferris Wheel in Yokohama City, Japan has a diameter of 100.0 meters. It makes 1 revolution every 1.00 minute. Jamie is on the ride and has a mass of 90 kg.
 - a. What is the speed of a passenger that is rotating at this rate? *Answer: 5.2 m/s*
 - b. What is the normal force exerted on this passenger by the chair at the top of the ride? *Answer: 833 N*
 - c. At the bottom of the ride? *Answer: 931 N*

3. Racing on a flat track, a car going 21 m/s rounds a curve. The coefficient of friction between the car's tires and the road is 0.80. What is the radius of the curve? *Answer: 56 m*

4. A cord is tied to a pail of water and the pail is swung in a vertical circle with a velocity of 2.71 m/s. What is the radius of the circle if the magnitude of the normal force at the top of the swing is $\frac{1}{4}$ that of the force of gravity? *Answer: 0.60 m*
 - a. What is the force on the water by the pail at the bottom of the swing, if the mass of the water is 0.25 kg? *Answer: 5.51 N*

5. An inventor who dares to be different proposes to make a pendulum clock using a pendulum bob with a mass of 0.50 kg at the end of a thin wire of length 0.50 m. Instead of swinging back and forth, the bob moves in a horizontal circle with a constant speed. As it rotates it makes an angle of 30° with the vertical as shown.
 - a. What is the tension in the wire? *Answer: 5.7 N*
 - b. What is the velocity of the pendulum? *Answer: 1.2 m/s*



6. Two bowling balls have their centers 2.0 m apart. One ball has a mass of 8.0 kg. The other has a mass of 6.0 kg. What is the gravitational force between them?
Answer: $8 \times 10^{-10} \text{ N}$
7. The gravitational force between two electrons 1.00 m apart is $5.42 \times 10^{-71} \text{ N}$. Find the mass of an electron.
Answer: $9.0 \times 10^{-31} \text{ kg}$
8. A small sphere with a mass of 0.100 kg is placed 0.400 m to the right of a 5.00 kg sphere and 0.600 m to the left of a 10.0 kg sphere. What is the net gravitational force on the 0.100 kg sphere if the centers of all three spheres are on the same line?
Answer: $2.5 \times 10^{-11} \text{ N to the left}$
9. Rhea, one of Saturn's moons, has a radius of 765 km and the acceleration due to gravity of 0.278 m/s^2 at its surface. What is the mass of Rhea?
Answer: $2.4 \times 10^{21} \text{ kg}$
10. Venus is often referred to as Earth's sister planet because it has a similar size and mass. What is the acceleration due to gravity on Venus? *Answer: 8.9 m/s^2*
11. Saturn has a number of moon's, the biggest of which are Titan, Rhea, Dione, and Tethys. Dione and Tethys are almost the same size, but Dione is 377,000 km from Saturn while Tethys is 295,000 km from Saturn. If Tethys has an orbital period of 1.9 days, what is the orbital period of Dione? *Answer: 2.7 days*
12. 51 Pegasi is a yellow star approximately 42 light-years from earth. 51 Pegasi has a planet known as 51 Peg b orbiting around it with a radius of 0.05 A.U. ($7.5 \times 10^6 \text{ km}$). It takes this planet 4 days to orbit its star. Assuming that the mass of 51 Peg b is half the mass of Jupiter, what is the mass of its star, 51 Pegasi?
Answer: $2.1 \times 10^{30} \text{ kg}$

Name	Average Radius (m)	Mass (kg)	Mean Distance from Sun (m)
Sun	696×10^6	1.99×10^{30}	—
Mercury	2.44×10^6	3.30×10^{23}	5.79×10^{10}
Venus	6.05×10^6	4.87×10^{24}	1.08×10^{11}
Earth	6.38×10^6	5.97×10^{24}	1.50×10^{11}
Mars	3.40×10^6	6.42×10^{23}	2.28×10^{11}
Jupiter	71.5×10^6	1.90×10^{27}	7.78×10^{11}
Saturn	60.3×10^6	5.69×10^{26}	1.43×10^{12}
Uranus	25.6×10^6	8.66×10^{25}	2.87×10^{12}
Neptune	24.8×10^6	1.03×10^{26}	4.50×10^{12}
Pluto	1.15×10^6	1.5×10^{22}	5.91×10^{12}

6.2 CIRCULAR MOTION REVIEW

1. (G1) A jet plane traveling 1800 km/hr (500 m/s) pulls out of a dive by moving in an arc of radius 6.00 km. What is the plane's acceleration in g's?
Answer: 4.25g up
2. (G4) A horizontal force of 280 N is exerted on a 2.0-kg discus as it is rotated uniformly in a horizontal circle (at arms length) of radius 1.00 m. Calculate the speed of the discus.
Answer: 12 m/s
3. (G7) What is the maximum speed with which a 1050-kg car can round a turn of radius 70 m on a flat road if the coefficient of friction between the tires and road is 0.80?
Answer: 23 m/s
4. (G8) A ball on the end of a string is cleverly revolved at a uniform rate in a vertical circle of radius 85.0 cm. If its speed is 4.15 m/s and its mass is 0.300 kg, calculate the tension in the string when the ball is...
 - a. At the top of its path. *Answer: 3.14 N*
 - b. At the bottom of its path. *Answer: 9.02 N*
5. (G9) How large must the coefficient of friction be between the tires and the road if a car is to round a level curve of radius 85 m at a speed of 95 km/hr?
Answer: at least 0.84
6. (G11) A coin is placed 11.0 cm from the axis of a rotating turntable of variable speed. When the speed of the turntable is slowly increased, the coin remains fixed on the turntable until a rate of 36 rpm is reached, at which point the coin slides off. What is the coefficient of static friction between the coin and the turntable.
Answer: 0.16
7. (G13) A 1000-kg sports car moving at 20 m/s crosses the rounded top of a hill (radius = 100 m). Determine:
 - a. The normal force on the car. *Answer: 5.8×10^3 N*
 - b. The normal force on the 70-kg passenger *Answer: 4.1×10^2 N*
 - c. The car speed at which the normal force equals zero.
Answer: 31 m/s
8. (G21) A pilot performs an evasive maneuver by diving vertically at 310 m/s. If he can withstand an acceleration of 9.0g's without blacking out, at what altitude must he begin to pull out of the dive to avoid crashing into the sea?
Answer: 1.1 km
9. (G25) Calculate the force of gravity on a spacecraft 12,800 km (2 earth radii) above the Earth's surface if its mass is 1400 kg. *Answer: 1.52×10^3 N*

10. (G27) A hypothetical planet has a radius 2.5 times that of Earth, but has the same mass. What is the acceleration due to gravity near its surface?

Answer: 1.6 m/s^2

11. (G34) Calculate the effective value of g , the acceleration due to gravity, at 3200 m and 3200 km above the Earth's surface.

Answer: 9.8 m/s^2 , 4.3 m/s^2

12. (G35) Four 7.5-kg spheres are located at the corners of a square of side 0.60 m. Calculate the magnitude and direction of the gravitational force on one sphere due to the other three.

Answer: $2.0 \times 10^{-8} \text{ N}$ toward center of the square

13. (G51) Use Kepler's laws and the period of the moon (27.4 days) to determine the period of an artificial satellite orbiting near the Earth's surface.

Answer: 0.0587 days

14. (G53) Neptune is an average distance of 4.5×10^9 km from the sun. Estimate the length of the Neputunian year given that the Earth is 1.50×10^8 km from the Sun on average.

Answer: $1.6 \times 10^2 \text{ yr}$

15. (G54) Determine the mass of the Earth from the known period and distance of the Moon.

Answer: $5.98 \times 10^{24} \text{ kg}$