Unit 3 – Dynamics
Physics 30S

Teulon Collegiate Institute
Mrs. Kornelsen

Grade 11 Physics – Dynamics Introduction

Think about it:

If you were attached to a massive helium balloon (or many balloons), could you eventually float out into deep space? Explain what you think and why.

Highest skydive:

On August 16, 1960, Joe Kittinger, attached to a helium balloon, lifted 102,800 feet (31,330 m). From that height he jumped out; free falling for 4 minutes and 36 seconds, reaching a maximum speed of 614 mph (988 km/h). At this point he opened his parachute. His total descent took 14 minutes.

Answer:

No, you would not float out into deep space. Consider the forces acting on the person, lift from the helium balloon and the force of gravity. The higher the person floats up away from the Earth, the smaller the force of gravity acting on the person would be, because the distance between the person and the Earth is increasing. The lift force acting on the person is not changing (we will assume the balloon is not leaking helium). Once the force of gravity and the lift force are equal in magnitude, the result will be no net force, and therefore no acceleration and the person will not move further away from the Earth.

Website:

http://www.youtube.com/watch?v=1VdSeDqU3EY&feature=related

Watch Mythbusters Phone Book test

Grade 11 Physics – Four Fundamental Forces

1) Strong Nuclear Force

- Attractive force
- Hold protons and neutrons in the nucleus of the atom
- Extremely strong force that overcomes the repulsive force between two protons
- Only acts at short ranges

2) Weak Nuclear Force

- Attractive force
- Hold protons and neutrons in the nucleus of the atom
- Extremely strong force that overcomes the repulsive force between two protons
- Only acts at short ranges

3) Gravitational Force

- Attractive force
- All objects exert gravitational force
- Depends on the objects mass

4) Electromagnetic Force

- Force that charged particles exert on each other
- Attractive force

Newton's 3 Laws of Motion

Newton's 1st Law

An object at rest tends to stay at rest, and an object in motion tends to stay in motion, unless acted on by an unbalanced net force.

Newton's 2nd Law

The acceleration of an object produced by a net force is directly related to the magnitude of the force.

The acceleration of an object produced by a net force is inversely related to the mass of the object.

If you exert the same force on two objects of different mass, you will get different accelerations.

$$F = ma$$

$$m = \frac{F}{a}$$

Newton's 3rd Law

For every force there is an equal and opposite force.

Introduction to Forces and Newton's First Law

Words to Know

- Dynamics:

- Force:

Types of Forces

- Force of Gravity ($\vec{F}_g$):

- Force of Friction ($\vec{F}_F$):

- Normal Force ($\vec{F}_N$):

- Tension ($\vec{T}$):

Aristotle's Thoughts on Force

_____ is required to keep objects moving. If the force is removed, the object stops.

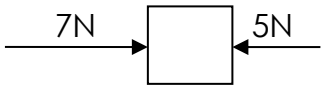
Newton's First Law (The Law of Inertia)

Objects at rest stay at rest and objects in motion stay in motion, unless acted on by a net force.

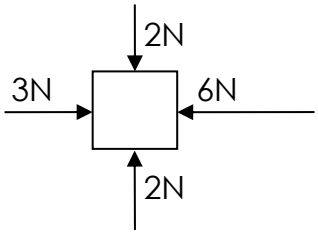
This means that if an object is not moving or if an object is moving, it will continue to move at a constant velocity unless a _____ causes a change in its motion.

Net Force ($\vec{F}_{Net}$): the _____ (or vector sum) of all forces. When all forces are balanced, $\vec{F}_{Net}$ = 0. This will occur when an object is _____, or moving at a _____.

Example: Calculate the net force on the following object



Example: Calculate the net force on the following object



Inertia: the tendency of objects to resist changes in their state of motion. The more mass an object has, the greater the inertia.

Examples: For the following situations, draw a free body diagram (a diagram labelling forces). Label all the forces and write an equation for the net force.

1. A skydiver falls downward through the air at a constant velocity.

2. A rope lifts a bucket at a constant speed.

Grade 11 Physics – Newton's first Law

1. A person is driving in their car at 100km/h when they hit a tree. Because they failed to wear a seatbelt, they wind up in the windshield.
    a. What did the tree exert the force on – the car or the driver? Which will stop moving first?
    b. Why does the driver continue moving even after the car stops? Neglecting friction and air resistance, how fast will the driver be going when they strike the windshield?
    c. In terms of Newton's first law, explain how a seatbelt would have prevented the driver from hitting the windshield?

2. Explain why whiplash occurs when the victim's vehicle is struck from behind.

3. A fastball blazes across home plate with a constant velocity of 160km/h. What is the net force acting on it?

4. You are driving your car and your wallet is sitting loose on the dash in front of you. You make a sudden 90° left turn and your wallet slides across the dash and winds up flying out the passenger window. Explain the motion of the wallet.

5. A rocket is sitting motionless on its launch pad.
    a. What is the net force acting on it? What is the force that opposes the force of gravity? Sketch the rocket on the launch pad, showing the forces acting on it.
    b. The rocket's engine is ignited an the rocket gains velocity. Is there a net force acting on it? Which force is bigger – the thrust of the engine or the force of gravity? Sketch the rocket as it gains velocity, showing the forces acting on it. (Ignore air resistance)
    c. In deep space, far removed from the gravitational pull of any object, the rocket's engine is shut down. Is there a net force acting on the rocket? Will the rocket speed up or slow down? How far will it travel?

6. A car follows a circular path while travelling at a constant speed.
    a. Why is it correct to say that the velocity of the car is changing?
    b. Is there a net force acting on the car?

7. According to Newton's first law, if someone has a piece of food lodged in their throat and is chocking, would striking them sharply on the back help? Explain.

8. Use Newton's first law of motion to explain what will happen in situations a – c. Then describe what will happen in situation d and explain why it is different.
    a. A car attempts to stop at a traffic light on an icy street.
    b. A truck attempts to turn a corner on an icy highway.
    c. A passenger in a car does not have the seatbelt buckled when the car runs into a snowdrift.
    d. An airline passenger attempts to sip a cup of coffee when the airplane suddenly drops down one meter.

9. For which of the following situations does the unbalanced force have a value of zero?
    a. A ball accelerates down a hill.
    b. A car travels along a straight, level highway with the cruise control set at 100km/h.
    c. A boulder falls from the edge of a cliff to the lake below.
    d. A book is at rest on a shelf.
    e. A communications satellite is located in an orbit such that it remains in the same spot above the Earth at all times.

10. For each of the situations in question 9, where the unbalanced force was not zero, describe the source of the unbalanced force.

Do Learning Activity 1.3 – Newton's First Law

Grade 11 Physics – Writing Equations for Net Force

When solving force problems, you are always required to write an equation for that situation. This formula will be used to solve the problem. There are three things you must think about when writing equations:

1. What are the forces involved in the problem?
2. Which forces do I need to use to solve the problem?
   Hint: usually you use the direction things are moving in the question.
3. How do I incorporate the direction of the forces?

Example: You and your sister are fighting over a large old refrigerator box, you pull with a force F_A, toward the East and your sister with a force F_B, toward the West. You are stronger, and pull with more force.

(a) Draw a diagram labeling all forces involved.

(b) Write an equation for the net force on the box.

Example: Your car gets stuck in the snow. You try to push it out with a force, F_A, toward the North. Two of your friends are also helping you push, with forces F_B and F_C, both also toward the North.

(a) Draw a diagram labeling all forces involved.

(b) Write an equation for the net force on the car.

Grade 11 Physics – Writing Equations for Net Force Questions

1. A rocket moves upwards, the engine applying a thrust, F_T, upward. Air resistance is acting on the rocket, F_A, downward.
    a. Draw a diagram labeling all forces involved.

    b. Write an equation for the net force on the box.

2. You want to remove a large rock from the garden. You wrap two ropes around it, and you and your friend each pull one rope East. You pull with a force, T_A, and your friend with a force, T_B.
    a. Draw a diagram labeling all forces involved.

    b. Write an equation for the net force on the rock.

3. A car skids to a stop on the highway, while moving North.
    a. Draw a diagram labeling all forces involved.

    b. Write an equation for the net force on the car.

Grade 11 Physics – Free Body Diagrams

1. Free fall without air friction

2. Free fall with air friction

3. An object resting on top of a table

4. An object on a frictionless table being pulled to the right

5. An object pulled to the right on a surface with friction. Assume that the pull to the right is larger than the force of friction

Grade 11 Physics – More Free Body Diagrams

Remember:

- The force of gravity points downward, toward the center of the Earth.
- The normal force is always perpendicular to the surface the object is in contact with.
- Friction is always parallel to the surface and opposite of the direction the object is moving

Example: Draw a free body diagram for the following situations. If possible, try to draw longer arrows for larger forces.

6. A box is dropped from 100m above the ground and is falling at a constant speed.

7. A hockey puck is sliding down an ice rink (which unfortunately is slanted).

8. A box is being pulled up a ramp at a constant speed.

Assignment 3.2 – Free body diagrams

Grade 11 Physics – Writing Equations for Net Force Questions

1. A rocket moves upwards, the engine applying a thrust, F_T, upward. Air resistance is acting on the rocket, F_A, downward.
    a. Draw a diagram labeling all forces involved.

    b. Write an equation for the net force on the box.

2. You want to remove a large rock from the garden. You wrap two ropes around it, and you and your friend each pull one rope East. You pull with a force, T_A, and your friend with a force, T_B.
    a. Draw a diagram labeling all forces involved.

    b. Write an equation for the net force on the rock.

3. A car skids to a stop on the highway, while moving North.
    a. Draw a diagram labeling all forces involved.

    b. Write an equation for the net force on the car.

Grade 11 Physics – Newton's Second Law

If an unbalanced force acts on an object, it accelerates in the direction of the net force. The net force can be found by:

$$\vec{F}_{Net} = m\vec{a}$$

Units of Force: N (Newtons) and $N = \frac{kgm}{s^2}$

Balanced forces are when $F_{Net} = 0$

- This occurs when a = 0 because either the object is at rest or it has a constant velocity.

Unbalanced forces are when there is a net force and acceleration does not equal zero

- This means the velocity is changing

Example: Two children pull in opposite directions on a doll. One pulls with a force of 20.0N [E] and the other with a force of 5.00N [W]. Find the net force.

Example: A girl pushes horizontally on a 10.0kg box and it accelerates at 2.50m/s^2 [E]. If the force of friction is 50.0N [W], with what force is the girl pushing?

Note: Sometimes you may be asked to calculate force, but you do not have the acceleration of the object. Don't forget the Kinematics equations! Remember $\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$

Example: A car of mass 1250 kg is pushed forward by its tires with a force of 2750 N. A force of friction of 1530 N also acts on the car. What is the acceleration of the car?

Example: A car with a mass of 1175 kg is travelling at an initial velocity of 5.00 m/s East. During a time interval of 2.50 seconds, the car travels accelerates with a final velocity of 10.25 m/s East. A force of friction of 2150 N acts on the car. What is the force that is driving the car forward?

Grade 11 Physics – Newton's Second Law

1. Two horizontal forces, 225N and 165N are exerted on a canoe.
    a. If these forces are applied to the right, find the net horizontal force on the canoe.
    b. If these forces are applied in opposite directions, 225N [Left] and 165N [Right], what is the net force?

2. Three confused sleigh dogs are trying to pull a sled across the Alaskan snow. Alutia pulls east with a force of 35N, Seward also pulls east, but with a force of 42N. Another dog, Kodiak, pulls west with a force of 53N. What is the net force on the sled?

3. Cam is learning how to ice-skate, he wants his mom to pull him along so that he has an acceleration of 0.80m/s^2[North]. If Cam's mass is 27.2kg, what force does his mom need to pull him? (Ignore the force of friction)

4. Tom and Ron simultaneously grab a 0.75kg piece of rope and begin tugging on it in opposite directions. If Tom pulls with a force of 16.0N [East] and the rope accelerates away from him at 1.25m/s^2 [West], with what force is Ron pulling?

5. A 2.0 kg cart is moving along a frictionless surface. It is accelerated at 0.80 m/s^2 [South]. What is the force causing the acceleration?

6. A 3.80 kg cart has its friction balanced out by sloping the surface on which it sits. What will be the acceleration when pulled forward by a force of 0.600 N [East]?

7. A 3.0 kg cart on a level surface slows down at 0.15 m/s^2 [North]. What is the frictional force decelerating the cart?

8. The combined mass of you and a skateboard is 50.0 kg. If someone pulls you with a force of 40.0 N [East] and if the force of friction is 25.0 N [West] what acceleration will occur?

9. The combined mass of you and a skateboard is 50.0 kg. Someone pulls the skateboard so that it accelerates at 2.0 m/s^2 [East]. If the frictional force between the skateboard and the road is known to be 30.0 N [West], what is the pulling force?

10. A 50 000 kg rocket in space fires its engines for 60.0 s. The thrust of the engines is 200 000 N [up].
    a. What is the acceleration of the rocket?
    b. What is the final velocity of the rocket if the initial velocity of the rocket was 830 m/s [up].

11. An airplane needs to change its velocity. Its engine provides a thrust of 53.0 kN [North]. The mass of the ship is 80 000 kg (3 sig figs).
    a. What is its acceleration?
    b. For how long should it burn its rockets to increase its velocity by 300.0 m/s [North]?

12. A 400 000.0 kg space platform must be brought from a velocity of 7200 m/s [West] to 7500 m/s [West]. It will do this by firing a booster rocket with a thrust of 100 000.0 N [West]. For how many seconds must the rocket burn in order to achieve this velocity increase?

13. A 2.0 kg cart traveling at 1.2 m/s [East] comes to rest in 8.0 s. What is the frictional force acting on the cart?

14. When a 2000.0 kg Pontiac traveling at 30.0 m/s [South] skids on an asphalt highway, it will skid to a stop in 4.20 s. What is the force of friction between the road and the car?

15. The motor of a 1200 kg car causes a force of 1600 N [East] on its driving wheels. What will be its acceleration when:
    a. the forces of air resistance and friction together are 300.0 N [West]?
    b. the car is streamlined so that the air resistance and frictional forces are reduced to 150 N [West]?

16. How much force must be applied by the driving wheels of 2000.0 kg car to give it an acceleration of 2.0 m/s^2 [North], if the forces of friction and air resistance together are 600.0 N [South]?

Do Using Newton's Laws Lab

Grade 11 Physics – Newton's Third Law

Newton's Third Law: For every force there is an equal and opposite reaction force.

Example: A car with a mass of 1000kg is driving down a road and a mosquito with a mass of 0.0007kg hits the windshield. The mosquito exerts a force of 2N on the car. What is the acceleration of the mosquito *and* the car due to the force of the impact?

Example: Tom and John are standing beside each other on ice. Tom has a mass of 60kg and John has a mass of 40kg. One pushes the other with a force of 360N for 0.1s.

(a) What is the acceleration of each?

(b) What is the velocity of each after the 0.1s?

Grade 11 Physics – Newton's Third Law

1. A squirrel with an armful of nuts is sliding helplessly across a flat icy roof, getting dangerously close to the edge. Use Newton's third law to explain how she could save herself.

2. When jumping to hit a volleyball, your legs push down on the ground with a force of 400N.
    a. What is the name of the force pushing upward on you and how large is this upward force?
    b. Why does the Earth remain stationary when you push down on it (think about Newton's third law).

3. When throwing a chest pass, you accelerate a 1.5kg ball at $20 m/s^2$ toward the south. Calculate the force that the ball exerts on you. Why don't you accelerate as a result?

4. During the Grey Cup, the field is completely covered in ice. A 100.0kg running back and a 150.0kg defensive tackle are sliding toward each other and they collide. If the running back accelerates at $2.00 m/s^2$ [East], calculate the acceleration of the defensive tackle.

5. Read the following situations. Pick one of Newton's laws to explain what is occurring. State the law you are using.
    a. You shoot a gun and it leaves a bruise on your shoulder, why does this happen?
    b. You kick a soccer ball with a force of 10N and it accelerates away from you. What happens if you kick a very heavy rock with the same force?
    c. A child is on a skateboard moving 1.5m/s [East] when they hit a rock and the skateboard comes to a sudden stop. What happens to the child on the skateboard?
    d. If two cars collide, with the one travelling faster experience a larger force? Explain.
    e. Your car won't start, so you try to push it home. This is not too hard when the car is empty, what happens if you try to push it home when it's filled with all of your friends?

Do: Learning activity 3.7
Assignment 3.2
Learning activity 3.4

Grade 11 Physics – Mass and Weight

Mass:

Weight:

Weight can be calculated by:

Weight is often measured using a scale, such as a spring scale or a bathroom scale. The object whose weight is being measured is pulled down by the force of gravity until the upward force of the spring is equal to the gravitational force pulling down

Example: A small rocket has a thrust of 650N [up] after launching. If the mass of the rocket is 50kg, what is its acceleration?

Example: A 50.0kg person in an elevator is on a spring scale attached to the ceiling. What is the reading on the scale when the elevator is rising with an acceleration of $2.5 m/s^2$?

Example: A 50.0kg person in an elevator. What is the apparent weight if the elevator is accelerating at 3.00 m/s^2 upwards?

Grade 11 Physics – Mass and Weight

1. The engine of a 50.0 kg rocket malfunctions shortly after launch. Its thrust is reduced to 300.0 N. What will be the acceleration of the rocket?

2. A 5.0×10^2 kg rocket sits on a launch pad.
    a. What is the force of support that the launch pad exerts on the rocket?
    b. When the rockets are fired with a thrust of 12 kN, what will be the net force on the rocket?
    c. What will be the acceleration when the rocket thrust is 12.0 kN?

3. Suppose you hang a 1.0 kg mass on a short string that is attached to the bottom of a
   0 - 20 N force scale.
    a. What is the tension (force pulling up) on the string?
    b. If you were to pull upward on the scale so that the tension becomes 13 N, what will be the acceleration of the mass?
    c. If you allow the mass to accelerate downward at 4.0 m/s^2, what will be the tension on the string?

4. A Newton scale is attached to the ceiling of an elevator. An 80.0 kg person is attached to the bottom of the scale. What is the reading on the scale when the elevator is
    a. at rest?
    b. rising with an acceleration of 2.00 m/s^2?
    c. coming down with an acceleration of 3.00 m/s^2?
    d. moving upwards between floors at a constant 8.00 m/s?

5. The person in the previous problem notices that the maximum upwards force on the scale is 1050 N. What is the maximum upwards acceleration of this elevator?

6. The 80.0 kg person (from question 4) notices that the minimum upwards force on the scale is 680 N while descending in an elevator. What is the maximum downwards acceleration experienced?

7. On a newly discovered planet a 5.0 kg mass falls 6.0 m in 2.8 s. What is the
    a. average speed of the fall?
    b. final speed of the fall?
    c. acceleration of the mass during the fall?
    d. force of gravity on the mass?

8. A model rocket of mass 0.60 kg is launched by a rocket motor having a thrust of 20.0 N.
    a. What is the force of gravity on this rocket?
    b. What will be the net force on the rocket while the motor is firing?
    c. What will be the upward acceleration of the rocket?

Grade 11 Physics – The Force of Friction

$$F_F = \mu F_N$$

The coefficient of friction (μ):

If an object on a level surface:

Types of Friction:

1. Static Friction:

2. Kinetic Friction:

Example: A car is moving East and has an acceleration of $0.51 m/s^2$ [West]. If the mass of the car is 2000kg and the normal force between the car and the road is 17kN, what is the coefficient of friction?

Example: A box has a coefficient of friction of 0.11. If a force of 35N is needed to push it across the floor with a constant velocity, what is the mass of the box?

Example: A 50.0kg mass is on a level surface. The coefficients of static and kinetic friction are 0.450 and 0.400 respectively.

(a) How much force is needed to start the mass moving?

(b) Once it is moving, you continue to apply the same force, what is the acceleration?

Do: How Slippery is a Banana Peel Activity &
Friction Activity

Grade 11 Physics – The Force of Friction

1. A force of 4.0 N [East] is required to pull a block across a level surface at a steady rate. The normal force on the block is 18 N. What is the coefficient of friction?

2. If $\mu = 0.95$ for rubber on concrete, what is the maximum stopping force on a car riding on a concrete road if the force of gravity is 10 kN (2 sig figs)?

3. The acceleration of a 3.0 kg cart heading East on a level floor is 0.25 m/s^2 [West]. The normal force between the floor and the cart is 30 N. What is the coefficient of friction between the cart and the surface?

4. A 65kg mass is on a level surface. The coefficients of static and kinetic friction are 0.55 and 0.42 respectively. What is the force needed to make the mass start to move? If this force is applied once it starts to move, what is its acceleration?

5. The force between a 1500 kg car and the road is 15 kN. What is the acceleration when the brakes are locked on a wet asphalt road where the coefficient of friction is 0.65? Assume the car is driving East.

6. A 4000 kg (2 sig figs) tool shed on skids requires a force of 30 kN (2 sig figs) to move it along level ground at a steady speed. What is the coefficient of friction between the skids and the ground?

7. A 35kg mass is on a level surface. The coefficient of static friction is 0.47. If the acceleration of the mass is 0.78m/s^2, what is the coefficient of kinetic friction? Assume you are pushing the mass with the force needed to make it start to move.

8. What force is required to slide a 5.0 kg box over the floor at a steady speed if the coefficient of friction is 0.60?

9. A laboratory cart is known to have a coefficient of friction of 0.040. It has an unknown load on it. A 7.30 N force is required to pull it at a steady speed across the table. What is the combined mass of the cart and load?

10. A horizontal force of 2.0 N [North] is applied to a 1.5 kg cart on a horizontal surface. The coefficient of friction is 0.60. What is the acceleration of the cart?

11. What force must be applied to a 2000 kg car on a level road to give it an acceleration of 1.0 m/s^2 [East] if the coefficient of rolling friction of its wheels is 0.08?

12. A 3000 kg (2 sig figs) car accelerates along a level road at a rate of 1.5 m/s^2 [North] when 5500 N [North] of force is applied. What is its coefficient of friction?

Grade 11 Physics – Tension

Tension is the force caused by a string or a rope. Tension is like any other force and is calculated the same way. When dealing with tensions, be sure to think about the _____ carefully. When determining the direction of tension, there are always two possibilities, you need to use the one that applies to the problem you are trying to solve.

Example: You and a friend are in a tug of war, label the direction each of you feels the tension.

You and your friend each feel the tension in the rope, but you feel that tension in _____ directions. When solving a question involving tension, think about the object that is the subject of the question, and use the direction they would experience the tension (this will sometimes be given to you in the question)

Example: A 10.0kg block has two ropes attached to it. A child is pulling on each of the ropes. The tension in one rope is 15N [West] and the tension in the other rope is 20.0N [East]. What is the acceleration of the block? Assume a frictionless surface.

Example: A 55kg person in a tug of war feels a tension of 105N [East] in the rope. They are being accelerated at $0.41 m/s^2$ [East]. What is the coefficient of friction between the person and the ground?

Do Dynamics Assignment #1.doc
Prepare for Quiz

Grade 11 Physics – Tension

Include the force of friction in your calculations, unless the question states that it is a frictionless surface.

1. A car accelerates at 2.0m/s^2 [East] as it uses a rope to tow a 400.0kg trailer. The force of air resistance on the trailer is 1000.0N [West]. What is the tension in the tow rope? Assume a frictionless surface.

2. A 22kg object is attached to two ropes. One rope has a tension of 36N [South] and the object accelerates at 5.2m/s^2 [North]. If the surface is frictionless, what is the tension in the other rope?

3. A 36kg block is accelerating at 2.1m/s^2 [East]. If the tension in the rope pulling the block is 85N [East], what is the force of friction acting on the block?

4. A box is being pulled by a rope with a tension of 140.0N [East], and is accelerating at 0.380m/s^2 [East]. If the box has a mass of 41.0kg and the coefficient of friction is 0.310, what is the normal force on the box? Do this without calculating the force of gravity.

5. If a 72kg object has an acceleration of 0.71m/s^2 [North], and the tension in the rope pulling the object is 141N [North], what is the coefficient of friction between the object and the surface?

Grade 11 Physics – Terminal Velocity and Drag Forces

Terminal Velocity:

Drag Force:

As the speed _____ , the force of drag _____ .

Eventually, the force of drag and the force of gravity are equal. When the forces are balanced, the resulting acceleration is _____ .

Terminal velocity depends on:

When the terminal velocity is very high, the force of drag on an object can be found by:

Example: What is the terminal velocity of a 3.0kg object falling through the air, where air resistance can be found by $F_D=0.1v^2$?

Example: What is the velocity of a 4.0kg object falling through the air if air resistance can be found by $F_D=0.2v^2$ and has an acceleration of $4.1m/s^2$ [down]?

Grade 11 Physics – Terminal Velocity and Drag Forces

1. While circling within the eye of a hurricane, a helicopter drops a 45kg sensor that is designed to transmit weather conditions as it falls through the storm. As it falls, the sensor experiences a drag force found by $F_D = 0.1v^2$. What is the sensor's acceleration when its velocity is 40.0m/s [down]?

2. An engineer designs a jet boat with a mass of 6.0×10^2kg. The total drag force on the boat is given by $F_D = 0.1v^2$.
    a. What is the thrust the engine provides the boat to reach a terminal velocity of 40.0m/s [East].
    b. What is the maximum acceleration the boat can achieve with this thrust? (Hint: the maximum acceleration will occur when the drag force = 0).

3. A 400.0kg sled is powered across a frozen lake by a small rocket which provides 2500N of thrust. The coefficient of kinetic friction between the sled's runners and the ice is 0.15. The drag due to air resistance is given by the formula $F_D = 0.4v^2$. Find the sled's acceleration when its velocity is 30.0m/s.

4. A ping pong ball has a mass of 0.0300kg. When dropped, it reaches a terminal velocity of 2.00m/s [down]. What is the coefficient of drag?

Review Questions:

5. A 1500kg car has a maximum acceleration of $1.25m/s^2$ when empty. If loaded with 500.0kg of cargo, what would be its maximum acceleration?

6. A 5g object weighs 0.5N [down] on an unknown planet. What is the acceleration due to gravity on this planet?

Grade 11 Physics – Dynamics Review

1. (a) Use Newton's First Law to explain why stomping your boot on the ground is an effective way to remove snow from it.
   (b) Newton's Second Law basically states that applying a force to an object causes it to accelerate. If an object accelerates, its velocity is doing 1 of 3 things. List these 3 things.
   (c) As you walk, what is pushing you forward? Use Newton's Third Law to explain.

2. A 300kg trailer, while being towed, goes from 2.00m/s to 10.0m/s in 20.0s. Friction and air resistance act on it with forces of 200.0N and 1000.0N respectively. Find the tension in the trailer hitch.

3. You accelerate a 300.0g volleyball upwards at $4.0 m/s^2$. What force does the ball exert on you?

4. A 2000.0kg car travelling at 20.0m/s skids to a stop with its wheels locked over a 40.0m distance.
   a. How long did it take to stop? (Hint: first find its average velocity as it stops)
   b. Calculate its acceleration.
   c. Find the coefficient of friction between the tires and the road.

5. A 150.0kg space probe is designed to crash land on the Martian surface. It descends through the atmosphere with a constant velocity of 15.0m/s. Find the drag force acting on it if the acceleration due to gravity on Mars is $3.72 m/s^2$.

6. As a skydiver falls with their arms and legs tucked tightly against their body, the drag force on them is given by the equation $F_D = 0.3v^2$.
   a. Suppose they extend their arms and legs, what effect would this have on their terminal velocity?
   b. With their arms and legs still tucked tightly against their body, find their acceleration when their velocity is 10.0m/s. Assume their mass is 60.0kg.

7. A person is hanging from a spring scale, in an elevator. If the person has a mass of 75.0kg, find the force exerted by the scale if:
   a. the elevator is moving upward at a constant speed of 5.00m/s
   b. the elevator is accelerating downward at a rate of $2.00 m/s^2$.

8. The engine of a 50.0kg rocket malfunctions shortly after launch. Its thrust is reduced to 300.0N. What will be the resulting acceleration of the rocket?

9. A 500kg (2 sig figs) rocket sits on a launch pad.
    a. Calculate the force the launch pad exerts on the rocket.
    b. When the rockets are fired with a thrust of 12kN, what will be the net force on the rocket?
    c. What will be the acceleration when the rocket thrust is 12kN?

10. On a newly discovered planet, a 5.00kg mass falls (starting from rest) 6.00m in 2.80s. What is the
    a. average speed of the fall?
    b. final speed of the fall?
    c. acceleration of the mass during the fall?
    d. force of gravity on the mass?

11. A model rocket of mass 0.600kg is launched by a rocket motor having a thrust of 20.0N.
    a. What is the force of gravity on this rocket?
    b. What will be the net force on the rocket while the motor is firing?
    c. What will be the acceleration of the rocket?

Answers:

1. See your notes
2. 1320N
3. 1.2N
4. (a) 4.00s (b) -5.00m/s^2 (c) 0.510
5. 558N
6. (a) decrease (b) 9.3m/s^2 [down]
7. (a) 735N [up] (b) 585N [up]
8. 3.80m/s^2 [down] – this means it will slow down and then fall toward the ground
9. (a) 4900N (b) 7100N [up] (c) 14m/s^2 [up]
10. (a) 2.14m/s (b) 4.28m/s (c) 1.53m/s^2 (d) 7.65N
11. (a) 5.88N (b) 14.1N (c)23.5m/s^2