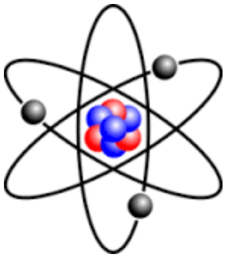
PHYSICS 11

Ms. Johnston
ELGIN PARK SECONDARY

Semester 1, 2019/20

Name: ___________

Block: ___



Course Outline 2019: Physics 11

Ms. Johnston, Rm. 106N
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Students will demonstrate an understanding and appreciation of the role of physics in society and develop knowledge, skills and methods employed by physicists. Emphasis will be placed on the applications of physics to everyday living and the skills needed in the workplace. Students will be engaged in the investigation of scientific questions and the development of plausible solutions.

Activities and strategies for learning will include teacher demonstrations, student hands-on labs, virtual computer-assisted labs and activities, student presentations, reading, answering questions, making notes, general daily review and preparation for labs, tests and quizzes. Through these activities, students will develop the following **curricular competencies**:

- **Questioning and Predicting –** make observations aimed at identifying questions about the natural world, and then formulating good hypotheses and predicting outcomes
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- **Planning and conductin**g **–** collaboratively and individually plan, select and use appropriate investigation methods to collect reliable data; design and perform labs and inquiries using the scientific method, using lab equipment effectively and safely
- **Processing and analyzing data and information –** making good observations, analyzing patterns and trends in data; construct, analyze and interpret graphs, models and diagrams
- **Evaluating –** lab analysis, evaluating cause-and-effect relationships, evaluate social, ethical and environmental implications with healthy skepticism while considering the validity of sources, evaluate experimental methods and conditions, including identifying sources of error or uncertainty, possible alternative explanations and conclusions.; critically analyze the validity of information
- **Applying and Innovating –** model complex systems, implement multiple strategies to solve real-life and conceptual situations
- **Communicating –** communicate clearly and confidently in an organized manner in a variety of forms (written, verbal, mathematically, etc.) through research projects, presentations, and working collaboratively

Embedded within these curricular competencies are the **core competencies** that reach across all aspects of the British Columbia curriculum: Communication, Thinking (creative and critical) and Personal and Social Awareness (positive personal and cultural identity, personal awareness and responsibility, social responsibility). These core competencies identify the sets of intellectual, personal, and social and emotional proficiencies that all students need to develop in order to engage in deep and life-long learning.

Course Content	
Introduction to Physics	Measurements of science, degree of uncertainty, displaying data, and manipulating equations
Kinematics and Dynamics	Describing motion, forces, vectors, projectiles, universal gravitation
Mechanical and Heat Energy	Work, energy and power; mechanical energy and thermal energy
Electrical Energy	Electrostatics, current electricity, electrical energy and power
Waves and Sound	Transfer of energy from one place to another; properties of waves and transmission of sound.

Grading and Evaluation

First Term Mark

a) Tests (60%)
Includes quizzes and chapter/section exams. Students are responsible for completing exams missed. Expect to write exams after school or at lunch upon the day of your return.

b) Labs and Assignments (40%)
Formal and informal labs will be a large component of this course. Homework assignments will be collected occasionally. Any labs or assignments missed due to legitimate absences are the responsibility of the student and should be completed and handed in upon your return. Assignments handed in more than one week late, or after they have been marked and returned to students, will receive a maximum of a 'pass' grade (50%). Unless arrangements are made with Ms. Johnston, assignments and labs not handed in will result in a grade of 0%.

Final Grade

a) Final Exam (20% of the final grade)
All students are required to write the final exam in Physics. The final will be comprehensive and worth 25% of the final grade.

b) End of term mark (70% of the final grade)
The end of term mark of tests and labs will consist of 65% of the final grade.
Tests (40% of the overall mark)
Labs and Assignments (25% of the overall mark)

c) Project (10%)
The design and construction of a device that encompasses the concepts of this course (i.e., mousetrap car, hovercraft) will be assigned to all students. Half of the grade will be based on the engineering design and performance of the device, while the other half will be based on the build log and presentation of the physics behind it.

Late Policy

Being late causes you to miss important information and disturbs the learning of others. If you are late, **wait to be admitted** into the classroom, and then quietly join in with the class's activities. You are late if you are still walking into class when the bell rings! Recurring offenses will result in a call home and possible referral to office.

Technology

Cell phones, computers, and iPads will often be used for educational purposes during this class. However, inappropriate use of cell phones (i.e., texting/gaming/watching videos during instructional time) may result in the phone being taken away for the for remainder of the class. Repeated offenses will result in the cell phone being turned over to the office for pick-up at the end of the school day and contact home.

Office Hours

Students requesting additional assistance, or time to make up labs or tests may see me at lunch or after school, by appointment. To contact Ms. Johnston outside of school hours, please use email (Johnston_he@surreyschools.ca).

WEBSITE INFORMATION

Ms. Johnston maintains a website that includes links to the course notes, classroom expectations, and safety rules. A homework page is updated daily for absent students or for those unsure of their required work for the next day.

Access to the website is available through the school website; select Staff along the top button bar, and then click on Ms. Johnston's name. It can be accessed directly through the URL http://johnstonsd36.weebly.com

Chapter 2: Kinematics

- branch of Physics that deals with describing ________________.
- motion can be described in 3 ways:
  a) ________________
  b) ________________
  c) ________________

2.1 Displacement and Velocity

Distance

- the ________ between 2 points.
- expresses a quantity of measure (________ **quantity**).
- distances ________ in 1 direction.

Displacement

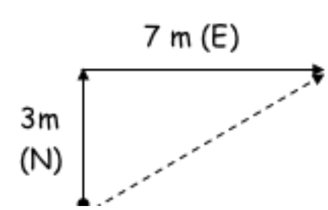
- the separation between an ________ and a ________________.
- indicates ________ and ________ (________ **quantity**).
- Used when distance traveled is not ________ to distance from start.
- **reference point** - zero point used to describe motion in a frame of reference.

Ex# 1: A train leaves the main station and travels 15 km east to the end of the line. It then reverses and travels 7 km west back towards the main station.

a) What distance did the train travel? ____
b) What is the train's displacement relative to the main station? _____

Ex# 2: A football player runs 3 m north and then 7 m towards the east.

a) What distance did the player travel? _____
b) What is the player's displacement relative to his starting position?



Speed

- The __________ an object travels in a unit of time
- ___________ speed is how fast your going at an instant of time (i.e., speedometer
- ___________ speed is the total distance traveled over total time.

$$\bar{v} = \frac{d}{t}$$

$\bar{v}$ = average speed (m/s)
d = total distance travelled (m)
t = total time taken for the motion (s)

Ex#1: A car travels 25km in 0.70 h, then travels 35 km in the next 1.50 h. What is the average speed of the entire trip?

Ex#2: How far will a woman travel in 15 minutes if she is driving her car down the highway at 24 m/s?

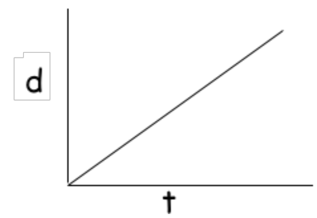
Ex#3: How long does it take a girl to travel 1800 m, if she is riding her bike at a rate of 2.50 m/s?

Velocity

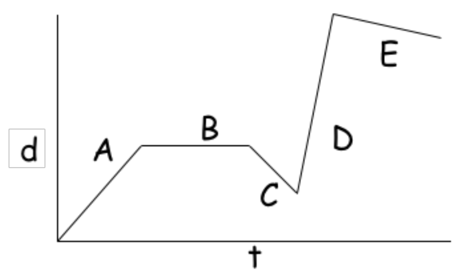
- indicates _________ and _________ of a moving object.
- has _________ and _________ (vector quantity)
- equal to the _________ of a displacement-time graph.

Constant Velocity

- achieved when the average velocity of an object is the _________ for all intervals (_________ motion).
- Constant velocities produce __________________on displacement-time graphs



- steeper slope = __________________
- horizontal slope = __________________
- positive velocity - indicates motion _________ from start point.
- negative velocity - indicates motion _________ start point.



v_A = ____________________

v_B = ____________________

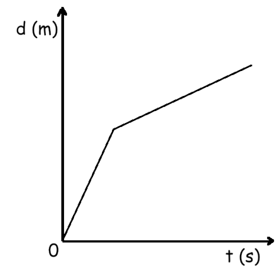
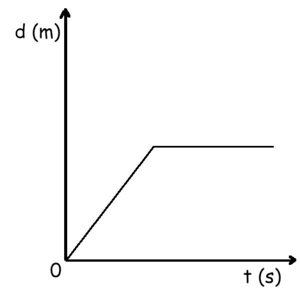
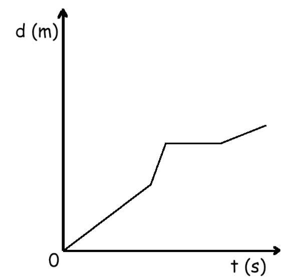
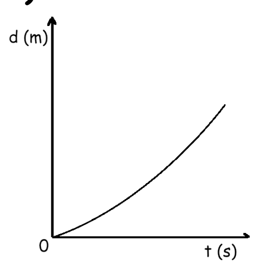
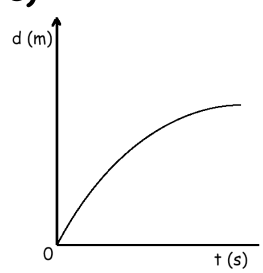
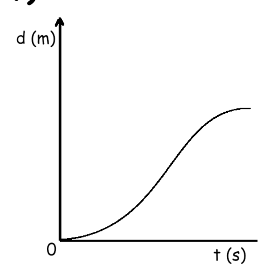
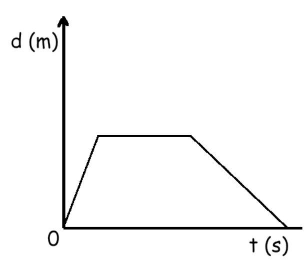
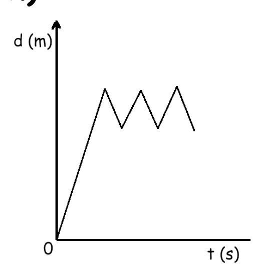
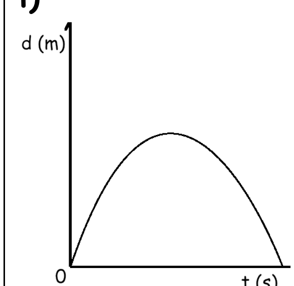
v_C = ____________________

v_D = ____________________

v_E = ____________________

Displacement-Time Graphs

Describe the kind of motion that is taking place in each of these displacement-time graphs with respect to the starting point. If the velocity is changing, state whether it is increasing or decreasing.

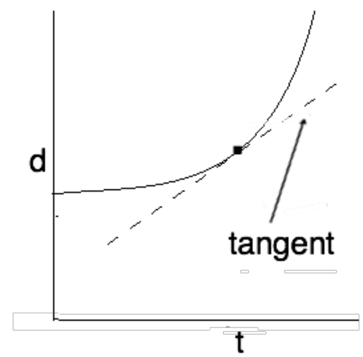
a) 	**b)** 	**c)** 
d) 	**e)** 	**f)** 
g) 	**h)** 	**i)** 

Slope of Changing Velocity

- when velocity changes the object is ________
- the line on a displacement-time graph will be ________.

ie. displacement-time graph

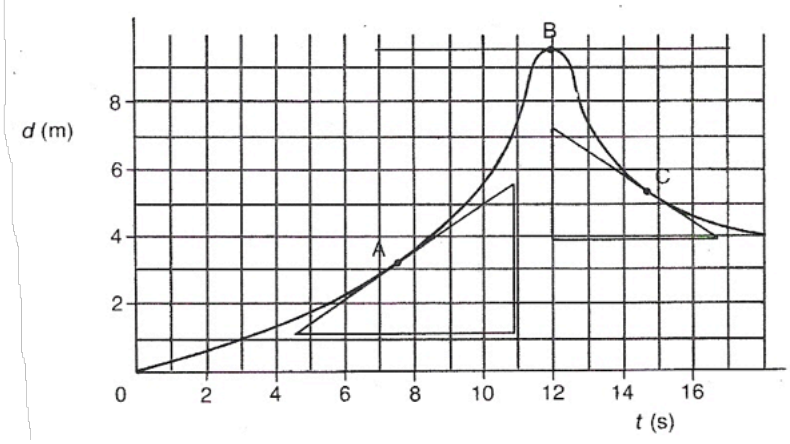
___________ - straight line that has the same slope as a point on a curve.



- Draw a line through a single point, but do not cross the graph – just touch the point.
- The velocity at that point (at one instant) is equal to the ____________ of the tangent.

Sample problem

On the following displacement-time graph, find the velocity at points A, B, and C by finding the slope of the tangent to the graph at each of the points.



v_A = **v_B =** **v_C =**

2.2 Acceleration

- the _____ at which ________ changes (increases or decreases).
- changing velocity = ________
- constant velocity = ________ acceleration

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{change in time}}$$

$$a = \frac{v_f - v_i}{t_f - t_i} = \frac{\Delta v}{\Delta t}$$

a = _________________ (m/s^2)
Δv = _________________ (m/s)
Δt = ________ taken for change (s)

NOTE: The Δ symbol can be read as 'change in' the variable after it.

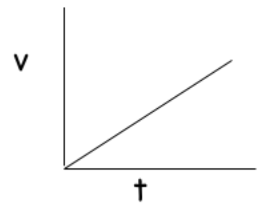
Ex#1: A runner accelerates from 0.52 m/s to 0.78 m/s in 0.050 s. What is her acceleration?

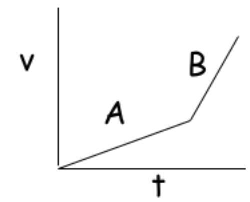
Ex#2: A car accelerates from rest at a rate of 50.0 cm/s^2 for 12.5 s. How fast is it now moving?

Ex#3: A turtle wants to accelerate from 2 mm/s to 8 mm/s. How long will it take, if its maximum acceleration is 3 mm/s^2?

Velocity-Time Graphs

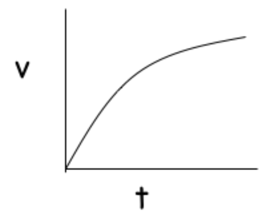
- acceleration is equal to the slope of a _______________ graph.

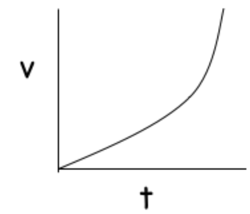




Positive Acceleration

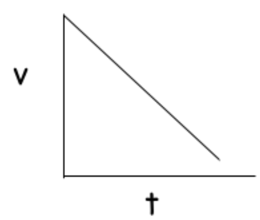
- constant acceleration produces a _________________ (increase in velocity is the same for each unit of time).
- changing velocity produces a _________________ (increase in velocity is not the same for each unit).

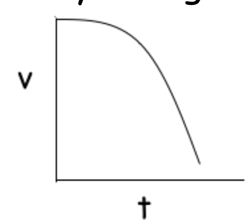




Negative Acceleration

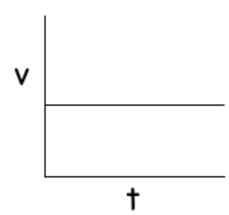
- slowing down produces _________ accleration
- _________ line when decrease in velocity is the same for each unit of time.
- _________ line when decrease in velocity changes with time





Zero Acceleration

• _________ remains constant



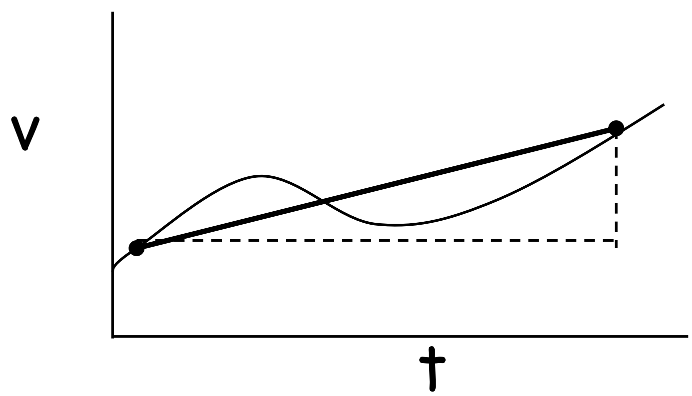
Change in Direction

• if ________ changes, the velocity changes and therefore, there is ___________

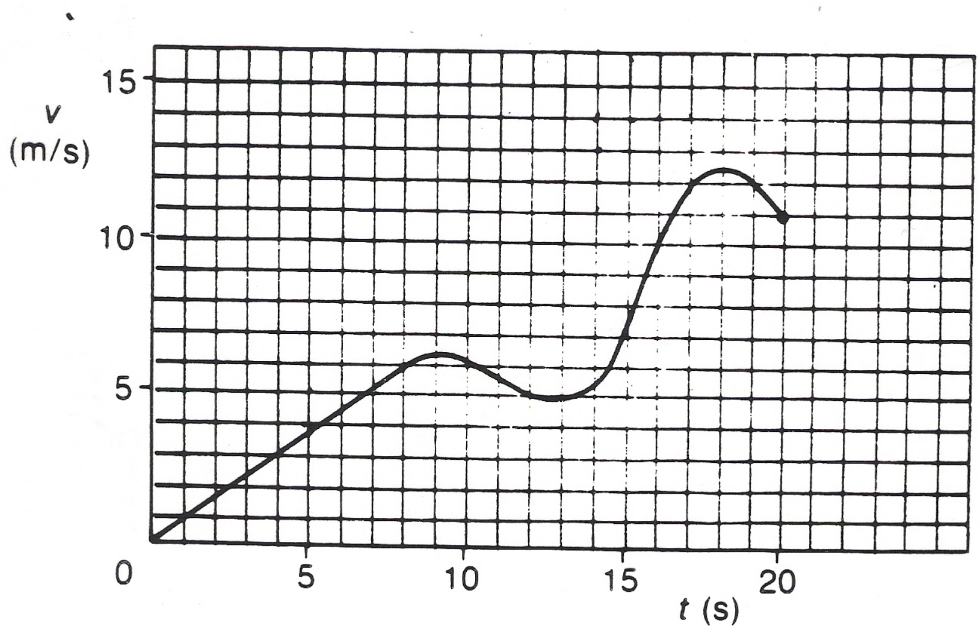
ie. Ferris wheel rotates at a constant speed in a circular motion, but the direction changes, resulting in acceleration.

Changing Acceleration

• curve on a V-T graph
• average acceleration = slope of the straight line joining two points on a curve of a V-T graph.



• instantaneous acceleration = slope of the ________ of a point on the graph.



1. At what times is the acceleration zero?

2. What is the acceleration for the first 7.0 s?

3. What is the average acceleration for each of the following time intervals:
   a) 5.0 to 15.0 s

   b) 9.0 to 13.0 s

   c) 15.0 to 20.0 s

4. What is the acceleration at each of the following times:
   a) 15.0 s

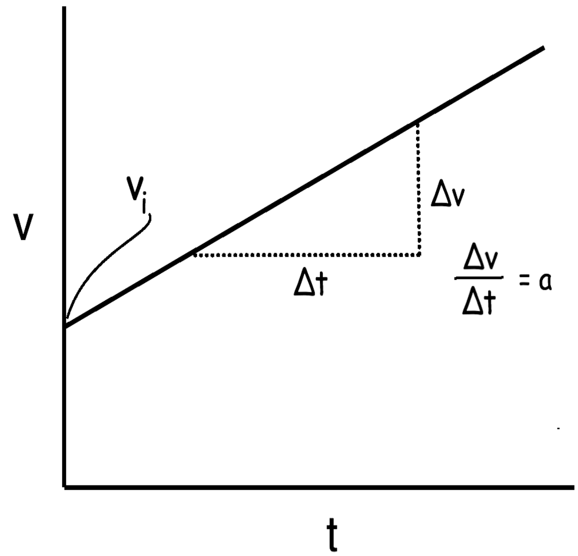
   b) 11.0s

   c) 17.0s

2.3 Uniform Acceleration

- a velocity-time graph of an object with uniform acceleration would produce a ___________________

- the general equation for a line is y = kx + b, where k is the slope and b is the y-intercept.
- In the following velocity-time graph,
  - y = v
  - x = t
  - k = slope = $\Delta v/\Delta t = a$
  - b = initial velocity, or v_i



Therefore:

$y = kx + b$

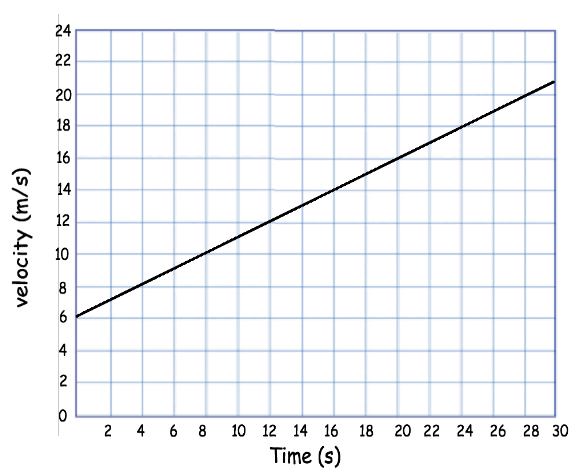
$v = at + v_i$

$$v_f = v_i + at$$

v_f = __________ velocity (m/s)
v_i = __________ velocity (m/s)
a = acceleration (m/s^2)
t = time (s)

Ex. For the adjacent graph, determine:

a) the acceleration



b) the specific equation for the graph

c) the time at which v = 16m/s

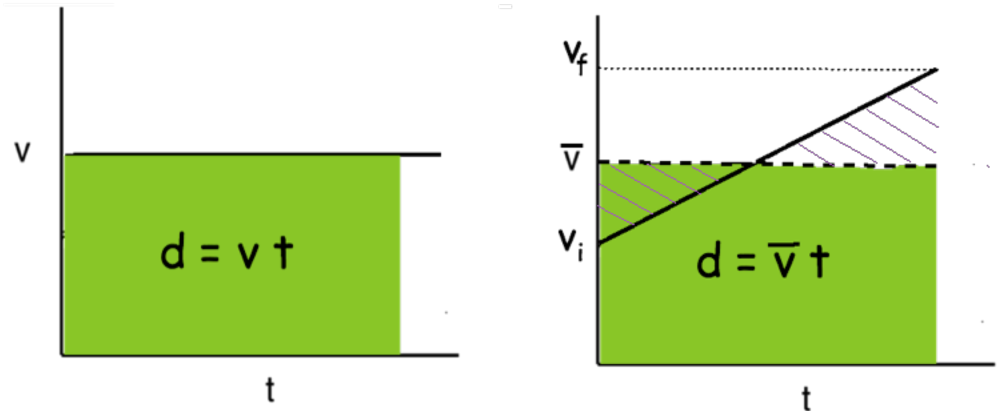
d) the velocity at t = 10 s

Displacement: Given Velocity and Time

- If we know the average velocity of an object, then we can determine the distance it travels using the equation:

$$\bar{v} = \frac{d}{t} \quad \text{or} \quad d = \bar{v}\,t$$

- This is equal to the **area** under the line on a v-t graph.



- If acceleration is constant, then the average velocity can be determined using the formula:

$$\bar{v} = \frac{v_f + v_i}{2}$$

And..

$$d = \left(\frac{v_f + v_i}{2}\right)t \quad \text{or} \quad d = \frac{1}{2}\left(v_f + v_i\right)t$$

Ex#1: How far does a dragster travel in 6.00 s, accelerating steadily from zero to 90.0m/s?

Ex#2: Two skateboarders accelerate steadily from 4.5 m/s to 11.5 m/s in 6.0 s. How far do they travel?

Displacement: Given Acceleration and Time

If $v_f = v_i + at$

and $d = \frac{1}{2}(v_f + v_i)t$

then $d = \frac{1}{2}\{ v_i + at + v_i\}t$

$d = \frac{1}{2}(2 v_i + at)t$

$$\mathbf{d = v_i t + \tfrac{1}{2} at^2}$$

Ex#1: A skier accelerates at 1.20 m/s^2 down an icy slope starting from rest. How far does she get in 5.0s?

Ex#2: What is the acceleration of an object that accelerates steadily from rest, traveling a distance of 1500 m over 10 min 10.0s, ?

Ex#3: How long does it take an airplane accelerating from rest at 5.0 m/s^2 to travel 300 m?

Displacement: Given Velocity + Acceleration

If $v_f = v_i + at$ rearranges to: $t = \frac{v_f - v_i}{a}$

and $\boldsymbol{d} = \left(\frac{v_f + v_i}{2}\right)\boldsymbol{t}$

$$\boldsymbol{d} = \left(\frac{\boldsymbol{v_f} + \boldsymbol{v_i}}{2}\right)\left(\frac{\boldsymbol{v_f} - \boldsymbol{v_i}}{\boldsymbol{a}}\right)$$

$$\boldsymbol{d} = \frac{(\boldsymbol{v_f} + \boldsymbol{v_i})(\boldsymbol{v_f} - \boldsymbol{v_i})}{\boldsymbol{2a}}$$

$$2ad = (\boldsymbol{v_f} + \boldsymbol{v_i})(\boldsymbol{v_f} - \boldsymbol{v_i})$$

$$2ad = v_f^2 - v_i^2$$

$$\boldsymbol{v_f^2 = v_i^2 + 2ad}$$

Ex#1: A bullet accelerates at 6.8 x 10^4 m/s^2 from rest as it travels the 0.80m of the rifle barrel. What velocity does the bullet have as it leaves the barrel?

Ex#2. A driver traveling at 95 km/h sees a deer standing on the road 150m ahead. He slams on his breaks and decelerates at a rate of -2.0 m/s^2. Will he stop in time?

Kinematics Practice

$v_f = v_i + at$

1. A golf ball rolls up a hill towards a mini-golf hole.

    a. If it starts with a velocity of +2.0 m/s and accelerates at a constant rate of -0.50 m/s^2, what is its velocity after 2.0 s?

    b. If the acceleration occurs for 6.0 s, what is its final velocity?

    c. Describe in words, the motion of the golf ball.

2. A bus traveling at +30 km/h accelerates at a constant +3.5 m/s^2 for 6.8 s. What is the final velocity in km/h?

3. If a car accelerates from rest at a constant 5.5 m/s^2, how long will be required to reach 28 m/s?

4. A car slows from 22 m/s to 3 m/s with a constant acceleration of -2.1 m/s^2. How long does it require?

$d = 1/2\ (v_f+v_i)t$

5. A race car traveling at +44 m/s is uniformly accelerated to a velocity of +22 m/s over an 11 s interval. What is its displacement during this time?

6. A rocket traveling at +88 m/s is accelerated uniformly to +132 m/s over a 15 s interval. What is its displacement during this time?

7. A car accelerates at a constant rate from 15 m/s to 25 m/s while it travels 125 m. How long does this motion take?

8. A bike rider accelerates constantly to a velocity of 7.5 m/s during 4.5 s. The bike's displacement is +19m. What was the initial velocity of the bike?

$d = v_i t + \frac{1}{2} at^2$

9. An airplane starts from rest and accelerates at a constant $+3.00 \text{ m/s}^2$ for 30.0 s before leaving the ground. What is its displacement during this time?

10. Starting from rest, a race car moves 110 m in the first 5.0 s of uniform acceleration. What is the car's acceleration?

11. A driver brings a car traveling at +22 m/s to a full stop in 2.0 s. Assume its acceleration is constant.
    a. What is the car's acceleration?

    b. How far does it travel before stopping?

12. 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 $+0.40 \text{ m/s}^2$ for 12 s. How far does she move down the hill during this time?

$v_f^2 = v_i^2 + 2ad$

13. An airplane accelerates from a velocity of 21 m/s at the constant rate of 3.0 m/s^2 over +535 m. What is its final velocity?

14. The pilot stops the same plane in 484 m using a constant acceleration of -8.0 m/s^2. How fast was the plane moving before braking began?

15. A person wearing a shoulder harness can survive a car crash if the acceleration is smaller than -300.0 m/s^2. Assuming constant acceleration, how far must the end of the car collapse if it crashes while going 101 km/h?

16. A car is initially sliding backwards down a hill at -25 km/h. The driver guns the car. By the time the car's velocity is +35 km/h, it is +3.2 m from its starting point. Assuming the car was uniformly accelerated, find the acceleration.

1a) +1.0m/s b) -1.0m/s 2) 120 km/h 3) 5.1s 4) 9.0s 5) 3.6×10^2m 6) 1.7×10^3m 7) 6.3s 8) +0.9m/s 9) 1350m 10) +8.8m/s^2
11a) -11m/s^2 b) 22m 12) 83m 13) 6.0×10^1m/s 14) 88m/s 15) 1.32m 16) +7.2m/s^2

2.4 Acceleration Due to Gravity

- Galileo showed that all objects fall to earth with a ________ acceleration, if air resistance can be ignored.
- **g** is the symbol for acceleration due to gravity.
- on the surface of the earth, g = _________ m/s^2
- (varies slightly, depending on distance from centre of earth)
- assuming no air resistance, all acceleration formulas apply to ___________ (substitute g for a).

Ex#1: The "Hellavator" ride at Playland falls freely for a time of 1.8 s.

a) What is the velocity at the end of the drop?

b) How far does it fall?

Ex#2: A ball is thrown straight upwards with an initial velocity of +12 m/s.

a) What is the ball's velocity at the top of its path?

b) how high does the ball go?

c) What is the ball's final velocity if it is caught at the same height it was thrown?

d) How long is the ball in the air?

Chapter 3: Forces

Dynamics: the study of why objects _______ as they do.

A force is a ________ or ________that acts on an object.

- Forces can ________ an object.
- Forces can ________ a moving object.
- Forces can change the ________ of an object.

Types of Forces

1) Contact forces: forces that touch an object

a) ____________ b) ____________ c) ____________

2) Action-at-a-distance Forces (no contact)

a) ____________ b) ____________ c) ____________

3.1 Force of Gravity

Measuring Mass

- Mass is measured in ________ (kg)
- ________ grams (g) = _____kilogram (kg)
- Mass is measured on a ____________scale
- Mass does not change – it is the same everywhere in the _____________

Weight (Force of Gravity)

- Amount of force on an object due to ________
- Depends on ________you are in the universe!
- Measured in ________ (N)
- 1 N is about the weight of one ________on earth

Measuring Force

- Force meters usually include a ________ or elastic that stretches or compresses.

    Ex. Spring scale

- 1 kg of mass would have a weight (force of gravity) of _______ N on Earth.
- To find the weight of an object on earth, you can _________its mass by 9.81 N/kg
- This value represents the _____________ field strength, g.

$$F_g = m\ g$$

Fg = weight or force of gravity acting on an object (N)
M = mass of object (kg)
g = gravitational field strength (9.81 N/kg)

Example: What is the weight of a 8.0 kg box on earth?

Practice:

1. What force does gravity exert on a 25.0 g plum on earth?
2. Determine the mass of a gold statue, if it has a weight of 2600 N.
3. The statue from question 2 is brought to the moon, where the gravitational field strength is 1.6 N/kg. How much would it now weigh?

Hooke's Law (Elastic Force)

- solids have a definite ___________and resists ___________in shape.
- Elastic force opposes the ___________, ____________, ____________of a material.

Hooke's Law

- If a _________ is exerted on an object such as a spring or block of metal, the object will be ___________ or _____________.
- If the stretch or compression, x, is relatively _________ compared to the length of the object, then x will be _______________ to the force, F, placed on the object.

- the elastic _________of a rubber band varies _________with the increase in ________.

$$F = kx$$

F = ___________(N)

k = ____________________(N/m)

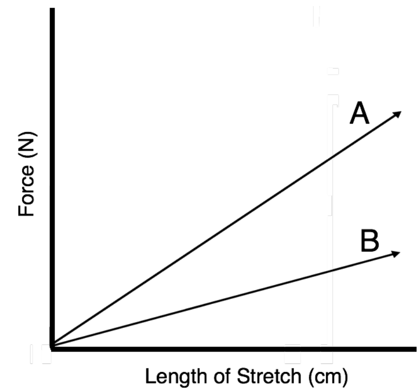
x = ______________(m)

Spring constant is dependent on:

a) ____________-of object being stretched.

b) ____________of the material.

Ex#1. On the adjacent graph, the stretch vs. force is plotted for two different rubber bands (A and B). Which of the two elastic bands would be thicker? How do you know?



Ex#2. How long will a 5.0 cm rubber elastic band be after a 5 N weight is attached to it? (K=10.0 N/cm)?

Ex#3. What is the spring constant of a metal bar, if a 3000N force compresses it from a length of 2.55 m to a length of 2.45 m?

Hooke's Law Problems

1. How much force would it take to stretch a steel bar with a spring constant of 2.1×10^7 N/m until it was 1.00mm longer?

2. What is the spring constant of a car spring if a 2500N force compresses it from a length of 50.0cm to a length of 40.0cm?

3. a) What force would be required to compress a 20.0cm long spring to 15.0cm if the spring constant is 30.0N/m?

   b) What mass, when placed on top of the vertical spring, would cause the same compression?

4. A spring is compressed 10m when a force of 5N is applied. How far does it compress when 10N is applied?

5. Peter is out hunting for a rabbit with his spring-loaded rock thrower. He pulls back on the spring with a force of 350N and it stretches 10cm. Determine the spring constant of the rock thrower.

6. Sally is standing on Planet Johnston where the acceleration due to gravity is 18.3 m/s^2. She holds a spring (k=100.0N/m) in her hand.
   a) If she puts a 1.2kg mass on the end of the spring, how far does it stretch?

   b) What mass would be required to stretch the spring 35 cm?

Answers: 1. 2.1×10^4N 2. 2.5×10^4N/m 3. a) 1.50N b) 0.153kg 4. 20m 5. 3.5×10^3N/m 6.a) 0.22m, b) 1,9kg

Law of Universal Gravitation

- Every particle is ____________to every other particle in the universe.
- The _____________of the attraction depends on the ___________of the objects and the __________between them.
- Gravity is a __________ force

  Ex. The force with which the earth pulls you down is _______ to the force with which your mass pulls the earth up!

$$F_g = \frac{G\, m_1\, m_2}{r^2}$$

F = ____________________between two objects (N)

m_1 = ___________-of one object (kg)

m_2 = __________of second object (kg)

r = ___________ between centres of the two objects (m)

G = ____________Nm^2/kg^2 (Gravitational Constant)

Ex. 1: What is the force of attraction between two apples, each with a mass of 0.50 kg, held 10 cm apart?

Ex.2: If M is the mass of the earth and r is the radius of the earth, rewrite the universal gravitation law to solve for g (Remember: F_g=mg)

Inverse Square Law

- The force of attraction between two objects is __________proportional to the _________of the distance between their centres.

  If you double the distance, you reduce the force to ______ the original amount; if you triple the distance, you reduce the force by _______ the amount.

Ex#1:The force of gravity on a rocket 10 000 km from the centre of the Earth is 900 N. What will the force of gravity on the rocket be when it is 30 000 km from the centre of the Earth?

Ex#2: The force of gravity on a horse is about 4000 N at the Earth's surface. How far above the Earth's surface would the horse have to be in order to have a weight of 1000 N?

Gravitational Force Questions

1. Two students are sitting 1.50 m apart. One student has a mass of 70.0kg and the other has a mass of 52.0 kg. What is the gravitational force between them?

2. What gravitational force does the moon produce on the earth if the centres of the Earth and moon are 3.84×10^8 m apart and the moon has a mass of 7.35×10^{22} kg?

3. Calculate the gravitational force on a 6.50×10^2 kg spacecraft that is 4.15×10^6 m above the surface of the earth.

4. The gravitational force between two objects that are 2.1×10^{-1}m apart is 3.2×10^{-6}N. If the mass of one object is 5.5×10^1 kg, what is the mass of the other object?

5. If two objects, each with a mass of 2.0×10^2 kg, produce a gravitational force between them of 3.7×10^{-6}N, what is the distance between them?

6. The weight of an astronaut on the surface of the earth is 750N.
   a) What is his weight when he is at the International Space Station, 250 km above the Earth's surface?

   b) How far above the earth's surface does he need to be before he is half his weight on earth?

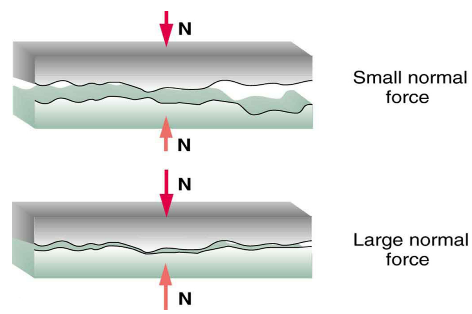
ANSWERS: 1) 1.08×10^{-7}N 2) $1{,}99 \times 10^{20}$N 3) 2.34×10^3N 4) 39kg 5) 0.85m 6) a) 690N b) 2.64×10^6m

3.2 Friction

- Friction is the force that __________motion between two surfaces in contact.
- **static friction** is the force that opposes the _________ of motion.
- **Kinetic friction** is the force needed to _________ an object in motion.
- Kinetic friction is ______________ less than static friction.
- To keep an object moving at a ___________ speed, you must apply an __________ but __________ force to the force of friction.

Sliding Friction

The force of friction, F_f, is proportional to the force applied ______________ to the surfaces, called the ____________ force, F_N.



$$F_f = \mu F_N$$

μ =_____________________

(constant that depends on 2 surfaces in contact)

F_N ________________ pushing 2 surfaces together, equal to W (N)

F_f = _____________________(N)

F_f is dependent on:

a) ___________________of the surface

b) ___________of the object

F_f is independent of:

a) size of the_________________________

b) size of the______________.

Ex#2. The coefficient of friction between 2 materials is 0.35. A 5.0 kg object is being pulled at a constant rate.

a) What is the normal force acting on the object?

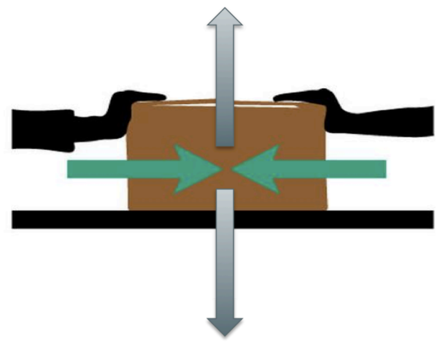
b) What is the force of friction?

Ex#2. It takes 50.0 N to pull a 6.00 kg object along a desk. What is the coefficient of friction?

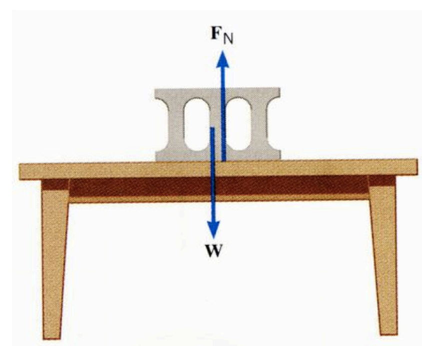
Ex#3. The coefficient of friction between a wooden block and a desk is 0.20. If a force of 0.75 N is needed to pull the block at a constant speed, determine the mass of the block.

Chapter 4: Newton's Laws of Motion

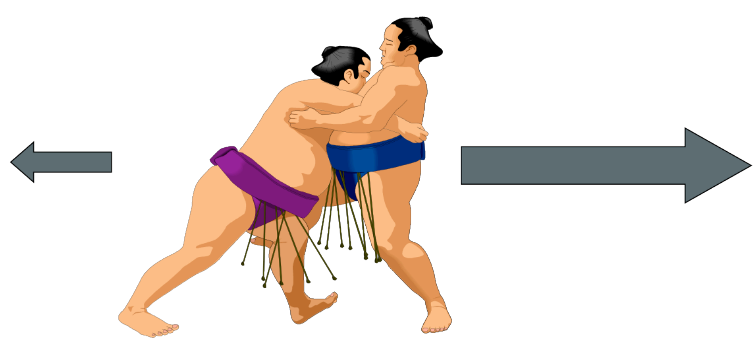
- a force diagram is a picture that shows the __________ and _________ of forces acting on an object



- the _________ of the arrow shows the size of the force (a longer arrow = a larger force)
- the __________ of the arrow shows the direction of the force
- forces always come in __________



- •When the forces are _________ they are acting in _________ direction with _________ strength
- •As a result the object ____________ move



- •When the forces are unbalanced they are acting in opposite direction with _____________ strengths
- •As a result the object ________ move

Newtons's Laws of Motion:

- Three laws summarize the relationship between __________ and ________

Newton's First Law: _______

- A body with ___________ forces acting on it, remains at ______ or moves with constant ________in a straight line.

Newton's Second Law: _____________

- A body with ___________ forces acting on it will accelerate at a rate directly proportional to the net _______on it and inversely proportional to its ________

a = F/m	or	F = ma

F =____________

m = ____________(kg)

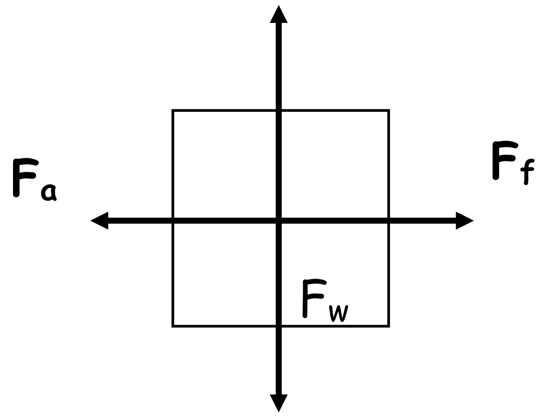
a = _____________(N/kg or m/s^2)

- ________and ______________(both__________) are in the same direction.
- _____force (resultant of all forces acting on a body) causes _________
- force that causes a mass of one ________to accelerate at a rate of one _________per _________= 1N

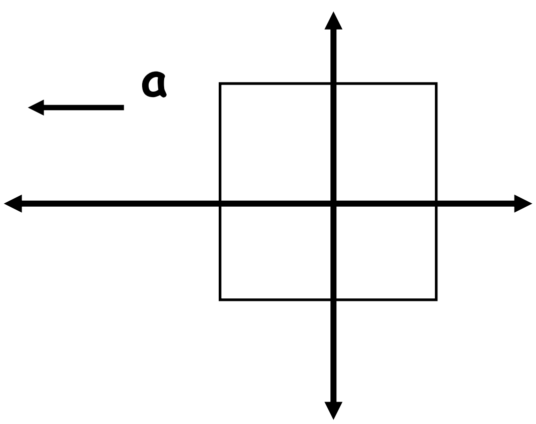
Ex#1: What is the net force required to accelerate a 1600 kg race car at 3.15 m/s^2?

Ex#2: A bus accelerates from rest to 30.0 m/s in 15s. If the net force acting on the bus is 25 000N, what is the mass of the bus?

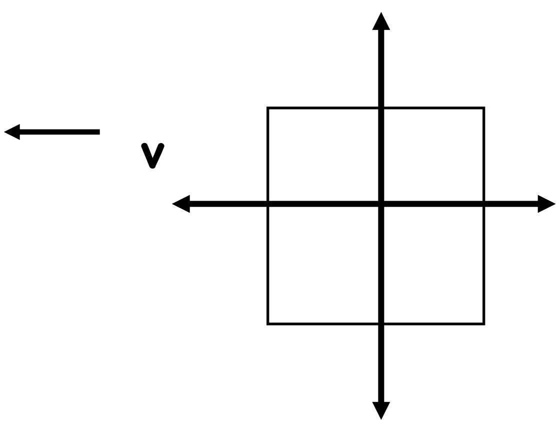
Net Forces Cause Acceleration



•If all forces are balanced on a stationary object, it will not move.

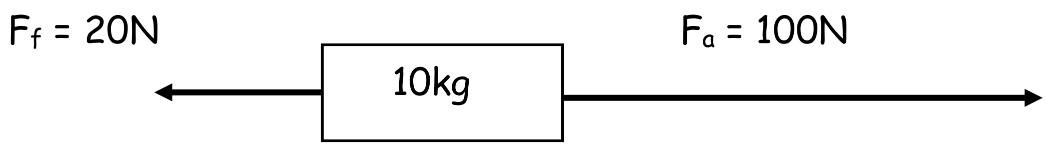


• For the object to move, you have to apply a force greater than the static frictional force. The forces are unbalanced and the object will accelerate.



•If F_a is then reduced so that it is equal to the sliding friction, opposing forces will be balanced once again and the object will continue to move at a constant velocity.

Ex.1 A 10 kg box is dragged along the floor with a force of 100 N. The force of friction is 20 N.



a) What is the force of gravity acting on the block? What is the normal force? Add those forces onto the force diagram above.

b) What is the net force acting on the block? In which direction is it acting?

c) What is the rate at which the block is accelerating?

Ex.2 What tension force is needed to accelerate a 20.0 kg box along a wooden floor (μ = 0.40) at a rate of 2.0 m/s^2?

Ex#3: The space shuttle has a mass of 2.0×10^6 kg. At lift off the engines generate an upward force of 3.0×10^7 N.

a) What is the weight of the shuttle?

b) What is the net force acting on the shuttle? In which direction is it acting? How do you know?

c) What is the acceleration of the shuttle when launched?

Ex#4: A parachutist has a mass of 65 kg. If the drag on the parachute is 590 N, what is the acceleration of the parachutist?

Terminal Velocity

When a body falls through a fluid, it __________ in speed.
However, a ______________velocity is eventually reached.

Terminal velocity occurs when the ___________________balances the _______________ of the fluid.

Depends on:

a) ________and _________of the falling object
b) _____________of the fluid (resistive force

Ex. #1. A skydiver in freefall has a mass of 75.0*kg*. What drag force would air resistance exert when the skydiver is at terminal velocity?

Ex. #2. A steel ball is falling at a constant speed through glycerin. The drag force is 30N. What is the mass of the ball?

Newton's 2nd Law Extra Practice Name: ________________

1. Suppose Joe, who weighs 625 N, stands on a bathroom scale calibrated in newtons.
   a) What force would the scale exert and in what direction?
   b) If Joe now holds a 50 N cat in his arms, what force would scale exert on him?
   c) After Joe puts down the cat, his father comes up behind him and lifts upward on his elbows with a 72 N force. What force does the scale now exert on him?

2. A 52 N sled is pulled across a cement sidewalk at constant speed. A horizontal force of 36 N is exerted. What is the coefficient of friction between the sidewalk and the metal runners of the sled?

3. The coefficient of sliding friction between rubber tires and wet pavement is 0.50. The brakes are applied to a 750 kg car traveling 30 m/s and the car skids to a stop.
   a) What is the size and direction of the force of friction that the road exerts on the car?
   b) What would be the size and direction of the acceleration of the car? Why would it be constant?
   c) How far would the car travel before stopping?

4. A force of 40.0 N accelerates a 5.0 kg block at 6.0 m/s^2 along a horizontal surface.
   a) How large is the frictional force?

   b) What is the coefficient of friction?

5. A rubber ball weighs 49 N.
   a) What is the mass of the ball?

   b) What is the acceleration of the ball if an upward force of 69 N is applied?

6. A small weather rocket weighs 14.7 N.
   a) What is its mass?

   b) The rocket is carried up into the sky by a balloon. The rocket is released from the balloon and fired, but its engine exerts an upward force of 10.2 N. what is the acceleration of the rocket?

7. An 873 kg dragster, starting from rest, attains a speed of 26.3 m/s in 0.59s.
   a) Find the average acceleration of the dragster during this time interval.

   b) What is the size of the average force on the dragster during this time interval?

   c) Assume the driver has a mass of 68 kg. What horizontal force does the seat exert on the driver?

8. A race car has a mass of 710 kg. It starts from rest and travels 40.0 m is 3.0 s. The car is uniformly accelerated during the entire time. What net force is applied to it?

9. A 4500 kg helicopter accelerates upwards at 2 m/s^2. What lift force is exerted by the air on the propellers?

10. The maximum force a grocery bay can withstand and not rip is 250 N. if 20 kg of groceries are lifted from the floor to the table with an acceleration of 5 m/s^2, will the bag hold?

11. A student stands on a bathroom scale in an elevator at rest on the 64^{th} floor of a building. The scale reads 836 N.
    a) As the elevator moves up, the scale reading increases to 935 N, then decreases back to 836 N. Find the acceleration of the elevator.

    b) As the elevator approaches the 74^{th} floor, the scale reading drops as low as 782 N. What is the acceleration of the elevator?

ANSWERS: 1. a) 625N (up); b) 657 N (up); c) 553 N (up); 2. 0.69; 3. a) -3.7×10^3N; b) -4.9m/s^2; c) 92m; 4. a) -10 N; b) 0.20; 5. a) 5.0 kg; b) 4.0 m/s^2 (up); 6. a) 1.5 kg; b) -3.0 m/s^2; 7. a) 45 m/s^2; b) 3.9×10^4 N; c) 3.1×10^3N; 8. 6.3×10^3N; 9. 5.3×10^4N; 10. No (F=300N); 11. a) 1.2 m/s^2; b) -0.63 m/s^2

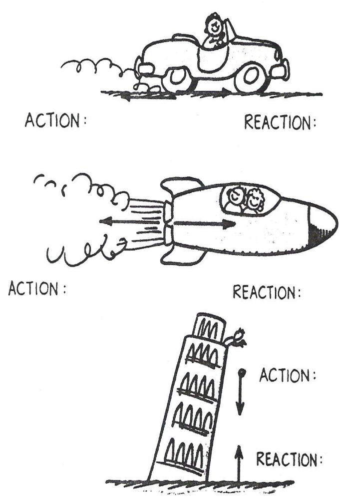
Newton's Third Law: ______________________

- Whenever one object exerts a _________on a second object, the second exerts an _________and ____________force on the first.

i.e., action force – hammer exerts a force on a nail

reaction force – nail exerts a force on the hammer.

Action and reaction forces are acting on different bodies.
__________on __________ determines acceleration (2^{nd} Law)

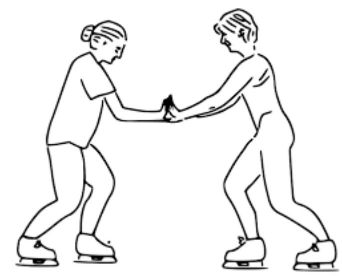


Action and Reaction of Different Masses

- Forces are ________in strength, but the acceleration is ____________on the masses.

Ex#1: Two girls on ice push each other. Andi weighs 55 kg while Jaime weighs 85 kg. They push each other with a net force of 150 N.

a) What is each girl's acceleration?



Andi	Jaime
m = 55 kg	m = 85 kg
F = 150 N	F = - 150 N
a =	a =

b) Why is the force acting on Jaime listed as negative?

c) Does it matter who pushes who?

Concepts in Physics - Newton's Laws

1. Galileo found that a ball rolling down one incline will pick up enough speed to roll up another. How high will it roll compared to its initial height if there were no friction?

2. The law of inertia states that no force is required to maintain motion. Why, then, do you have to keep pedalling your bicycle to maintain motion?

3. If an object has no acceleration, can you conclude that no forces are acting on it? Explain and draw a free body diagram to illustrate an example.

4. What is the effect of friction on a moving object? How is an object able to maintain a constant speed when friction acts upon it?

5. Suppose a cart is being moved by a certain net force. If a load is dumped into the cart so its mass is doubled, by how much does the acceleration change?

6. The force of gravity is twice as great on a 2 kg rock as on a 1 kg rock. Why then does the 2 kg rock not fall with twice the acceleration?

7. A rocket fired from its launching pad not only picks up speed, but its acceleration increases significantly as firing continues. Why is this so? (hint: About 90% of the mass of a newly launched rocket is fuel)

8. When a rock is thrown straight upward what is its acceleration at the top of its path?

9. When you jump up, the world really does recoil downward. Why can't this motion of the world be noticed?

10. Action and reaction forces are equal and opposite, so why don't they cancel one another and make the net forces greater than zero impossible?

4.4 Momentum

- the ______________ of motion.
- the product of _______and_________.

$$p=mv$$

p=____________, kg.m/s
m =_______, kg
v =_________, m/s

Ex#1: A baseball with a mass of 0.15 kg is moving at 27 m/s. What is the momentum of the baseball?

Ex#2: If a bowling ball has a mass of 5.5kg, what velocity would you give it in order to have the same momentum as the baseball?

Momentum and Newton's 1st Law

If no net force acts on a body, its velocity is _______. If an objects ______and ________do not change then its momentum is_________.

Momentum and Newton's 2nd Law

Newton's 2nd law describes how ________changes by a _______acting on it:

$$\boxed{F = ma}$$

If $a = \Delta v / \Delta t$

then $F = m(\Delta v / \Delta t)$

or $F\Delta t = m\Delta v$

Impulse ($F\Delta t$)

- the product of ___________and _______during which it acts.
- measured in N.s

Impulse-Momentum Theorem

- impulse given to an object is equal to the ________in momentum

Ex#1: What is the impulse exerted on a baseball if a bat exerts a force of 550 N for 0.007 s on the ball?

Ex#2: What force is required to stop a 1200 kg car in 12 s if the car is travelling 60 m/s?

Ex#3: A 0.144 kg baseball is pitched horizontally at 38.0 m/s. After it is hit by a bat, it moves horizontally at 38 m/s.

a) What impulse did the baseball deliver to the ball?

b) If the bat and ball were in contact for 0.80 ms, what was the average force exerted on the ball?

c) What is the average acceleration of the ball during its contact with the bat?

Momentum

Concept Review:

1. Is the momentum of a car traveling south different from that of the same car moving north at the same speed? Explain.

2. If you jump off a table, as your feet hit the floor you let your legs bend at the knees. Explain why.

3. Which has more momentum: a supertanker tied at a dock or a falling raindrop? Explain.

4. An archer shoots arrows at a target. Some of the arrows stick in the target while others bounce off. Assuming the mass and initial velocity are the same, which arrows give a bigger impulse to the target? (HINT: Consider the change of momentum of the arrow).

Problems

1. A compact car, mass 725 kg, is moving at +100 km/h.
   a. Find its momentum.

   b. At what velocity is the momentum of a larger car, mass 2175 kg, equal to that of the smaller car?

2. A snowmobile has a mass of 2.50×10^2 kg. A constant force is exerted on it for 60.0s. The snowmobile's initial velocity is 6.00 m/s and its final velocity is 28.0 m/s.

   a. What is its change in momentum?

   b. What is the magnitude of the force exerted on it?

3. The brakes exert a 6.40×10^2 N force on a car weighing 15680 N and moving at 20.0 m/s. The car finally stops.

   a. What is th car's mass?

   b. What is its initial momentum?

   c. What is the change in the car's momentum?

   d. How long does the braking force act on the cart to bring it to a halt?

ANSWERS: 1a) 2×10^4kgm/s b) 33km/h 2a) 5.50×10^3kgm/s b) 91.7N 3a) 1.60×10^3kg b) 3.20×10^4 kgm/s c) -3.20×10^4 kgm/s d) 50.0s

Conservation of Momentum

The ______momentum before any collision is the same as the _______ momentum after the collision. The momentum of the system is not changed, it is conserved.

Ex#1: A loaded 6000. kg railway car rolls at 2.0 m/s into an empty 3000. kg railway car. The empty car was moving at 3.0 m/s towards the loaded car.

a) Calculate the momentum of the loaded car.

b) Calculate the momentum of the empty car.

c) What is the total momentum of the system if both cars stick together when they collide?

d) What is the velocity of the system?

Ex#2: Sedin and Crosby are standing on the ice rink when they argue about a call. Crosby pushes Sedin and acquires a velocity of 3.0 m/s. If Sedin has a mass of 92 kg and Crosby has a mass of 87 kg, what is Sedin's velocity?

Conservation of Momentum Practice

1. Ball A has a mass of 10 kg and Ball B has a mass of 5 kg. Ball A, travelling at +4 m/s collides with a stationary Ball B, bounces back with a velocity of -2m/s.
   a. What is Ball A's momentum before collision?

   b. What is Ball B's momentum before collision?

   c. What is the total momentum of Ball A and B before collision?

   d. What is the Ball A's momentum after collision?

   e. What should Ball B's momentum be after collision?

   f. How fast will Ball B travel after the collision?

2. Ball C has a mass of 10 kg and Ball D has a mass of 5 kg. Ball C is travelling at +6 m/s when it collides with a stationary Ball D. Both balls stick together after collision.
   a. What is the total momentum of Ball C and Ball D before collision?

   b. What would the total momentum of Ball C and D be after collision?

   c. What is the total mass of Balls C and D?

   d. How fast will Balls C and D move after sticking together?

3. Ball E has a mass of 10 kg and Ball F has a mass of 5 kg. Ball E is travelling at +4 m/s when it collides with Ball F, which is travelling towards it at -10 m/s. After collision, Ball E is travelling at -6 m/s. What is Ball F's velocity after collision?

4. Ball G has a mass of 10 kg and is travelling at +5 m/s. After colliding with a stationary Ball H, Ball G bounces back with a velocity of -3 m/s, while Ball H is pushed forward with a velocity of +4 m/s. What is the mass of Ball H?

5. Ball J is travelling at +5m/s when it collides with Ball K, which has a mass of 2 kg and is travelling at -3m/s. After collision, the two balls move off together at a speed of +1 m/s. What is the mass of Ball J?

Conservation of Momentum

Concept Review:

1. Two soccer players come from opposite directions. They leap in the air to try to hit the ball, but collide with each other instead, coming to rest in midair. What can you say about their original momentum?

2. During a tennis serve, momentum gained by the ball is lost by the racket. If momentum is conserved, why doesn't the racket's speed change much?

3. Someone throws a heavy ball to you when you are standing on a skateboard. You catch it and roll backward with the skateboard. Explain using momentum conservation.

Additional Problems:

1. A 0.105 kg hockey puck moving at 48 m/s is caught by a 75 kg goalie at rest. With what speed does the goalie slide on the ice?

2. A 35.0 g bullet strikes a 5.0 kg stationary wooden block and embeds itself in the block. The block and bullet fly off together at 8.6 m/s. What was the original velocity of the bullet?

3. A 35.0 g bullet moving at 475 m/s strikes a 2.5 kg wooden block. The bullet passes through the block, leaving at 275 m/s. The block was at rest when it was hit. How fast is it moving when the bullet leaves?

4. A 0.50 kg ball traveling at 6.0 m/s collides head-on with a 1.00 kg ball moving in the opposite direction at a velocity of -12.0 m/s. The 0.50 kg ball moves away at -14 m/s after the collision. Find the velocity of the second ball.

ANSWERS: 1) 0.067m/s 2) 1.2×10^3m/s 3) 2.8m/s 4) -2.0m/s

DYNAMICS REVIEW

1. Which of Newton's laws best explains why motorists should buckle up?
   a. The first law
   b. The second law
   c. The third Law
   d. The law of gravitation

2. When you sit on a chair, the net force on you is…
   a. Down
   b. Up
   c. Zero
   d. Dependent on your weight

3. In the absence of an external force, a moving object will…
   a. Move with constant velocity
   b. Slow down and eventually come to a stop
   c. Go faster and faster
   d. Stop immediately

4. You are standing in a moving bus, facing forward, and you suddenly fall forward. You can infer from this that the bus's…
   a. Speed remained the same, but it is turning to the right
   b. Velocity increased
   c. Velocity decreased
   d. Speed remained the same, but it is turning to the left

5. A constant net force acts on an object. Describe the motion of the object.
   a. Increasing acceleration
   b. Constant velocity
   c. Constant acceleration
   d. Constant speed

6. If you blow up a balloon and then release it, the balloon will fly away. This is an illustration of…
   a. Newton's first law
   b. Newton's second law
   c. Galileo's law of inertia
   d. Newton's third law

7. A 20-ton truck collides with a 1000 kg car and causes a lot of damage to the car. In this situation,
   a. The force of the truck is equal to the force on the car.
   b. The truck did not slow down during the collision.
   c. The force on the truck is greater than the force on the car.
   d. The force on the truck is smaller than the force on the car.

8. An object of mass m sits on a flat table. The earth pulls on this object with force mg which we will call the action force. What is the reaction force?
   a. The table pushing up on the object with force mg.
   b. The table pushing down on the object with force mg.
   c. The object pushing down on the table with force mg.
   d. The object pushing upward on the Earth with force mg.

9. Mass and weight…
   a. Both measure the same thing.
   b. Are exactly equal.
   c. Are both measured in kilograms.
   d. Are two different quantities.

10. The acceleration due to gravity is lower on the Moon than on Earth. Which of the following is true about the mass and weight of an astronaut on the Moon's surface, relative to the Earth?
    a. Mass is less, weight is the same.
    b. Both mass and weight are the same.
    c. Both mass and weight are less.
    d. Mass is the same, weight is less.

11. A stone is thrown straight up. T the top of its path, the net force acting on it is…
    a. Greater than zero, but less than its weight.
    b. Greater than its weight.
    c. Equal to its weight.
    d. Instantaneously equal to zero.

12. An object of mass m is hanging by a string from the ceiling of an elevator. The elevator is amoving up at a constant speed. What is the tension on the string?
    a. Exactly mg.
    b. Less than mg.
    c. Greater than mg.
    d. Always acting on different objects.

ANSWERS: 1a, 2c, 3a, 4c, 5c, 6d, 7a, 8d, 9d, 10d, 11c, 12a

13. Calculate the net force and acceleration for the following cases. Include free body diagrams in your answer.

    a. A 0.65 kg ball that has been thrown up from the ground is at its maximum height.

    -6.4N, -9.8m/s^2

    b. A 2 kg book sitting on a table.

    0N, 0 m/s^2

    c. A 2 kg book on a frictionless table that is being pulled to the right by a horizontal force of 100 N.

    100N, 50m/s^2

    d. A 747 jumbo jet of mass 30 000 kg on the runway when the thrust from the engines is 40 000 N and the air resistance force is 2000 N.

    38000N, 1.3m/s^2

    e. A 2 kg book that is being pulled with a force of 10 N on a table with a coefficient of friction of 0.200.

    6.08N, 3.04 m/s^2

    f. A 100 kg rocket that is moving straight up with a thrust force of 60 000 N from its engines.

    59000N, 590m/s^2

14. When a shot-putter exerts a net force of 140 N on a hot, the shot has an acceleration of 19 m/s^2. Draw a free body diagram of the shot, and calculate its mass (ignore air resistance).

7.4kg

15. Imagine a spider with mass 7.0×10^{-5} kg moving downward on its thread. The thread exerts a force that results in a net upward force on the spider of 1.2×10^{-4} N. Draw a free body diagram of the spider and find its acceleration.

$1.7 m/s^2$

16. Together a motorbike and rider have a mass of 275 kg . The motorbike is slowed down with an acceleration of -450 m/s^2. What is the net force on the motorbike? Illustrate the forces acting on the bike in a diagram. Describe the direction of this force and the meaning of the negative sign.

-1.2×10^5N

17. A cardboard carton weighing 200 N is resting on a marble floor. If the coefficient of friction between the cardboard and the smooth marble is 0.20, how much force would it take to accelerate the box at a rate of 2.0 m/s^2? Draw a free body diagram showing the forces acting on the box. Include an arrow showing the direction of acceleration.

80.4N

Momentum Review

1. In the case of a heavy truck at rest and a skateboarder rolling,
   a) Which has the greater mass? _______________
   b) Which has the greater momentum? _________________

2. When the average force of impact on a object is extended in time, how does this change the impulse?

3. When you ride a bicycle at full speed, which has the greater momentum – you or the bike? Explain why you go over the handlebars if the bike is brought to an abrupt halt.

4. You can't throw a raw egg against a wall without breaking it, but you can throw it with the same speed into a sagging sheet without breaking it. Explain.

5. If you throw a heavy rock from your hands while standing on a skateboard, you roll backwards. Would you roll backwards if you didn't actually throw the rock but went through the motions of doing so? Explain.

6. A bug and the windshield of a fast-moving car collide. Explain whether the following statements are true or false.
   a) The forces of impact on the bug and the car are the same magnitude.
   b) The impulse on the bug and the car are the same size.
   c) The changes in speed of the bug and the car are the same.
   d) The changes in momentum of the bug and the car are the same size.

1. A fullback of mass 120 kg travelling at 20.0 m/s collides with another player and comes to rest in 1.5 s. What was the force of the impact?

(-1600 N)

2. A golf ball of mass 0.050 kg acquires a speed of 80.0 m/s when hit with a force of 3.0×10^3 N. How long was the club in contact with the ball?

(0.0013 s)

3. A 65 kg ice skater travelling at 6.0 m/s runs head-on into an 85 kg skater travelling in the same direction at 4.5 m/s. At what speed and in what direction do the ice skaters travel if the move together after the collision?

(5.2 m/s)

4. A 4.0 kg object travelling westward at 25 m/s hits a 15 kg object at rest. The 4.0 kg object bounces eastward at 8.0 m/s. What is the speed and direction of the 15 kg object?

(+8.8 m/s)

5. A bullet of mass 0.065 kg is fired from a 4.0 kg gun with a speed of 5.0×10^2 m/s. What is the recoil velocity of the gun?

(8.1 m/s)

6. A 62 kg child is sitting on a wagon full of bricks that has a mass of 150 kg. In order to move the wagon without touching the ground, the child throws two bricks each of mass 3.0 kg in the direction opposite to the direction the wagon is to go. How fast will the wagon move if the bricks are thrown at 2.0 m/s?

(0.058 m/s)

Chapter 5 – Vectors and Projectile Motion

Scalar Quantities - express only magnitude
ie. time, distance, speed

Vector Quantities - express magnitude and direction.

ie.	velocity	80 km/h, 58°
	displacement	10 km (E)
	acceleration	4.0 m/s^2, 27°
	force	100 N, 110°

- represented by an arrow. 
- length of arrow indicates magnitude(drawn to scale), arrowhead indicates direction.

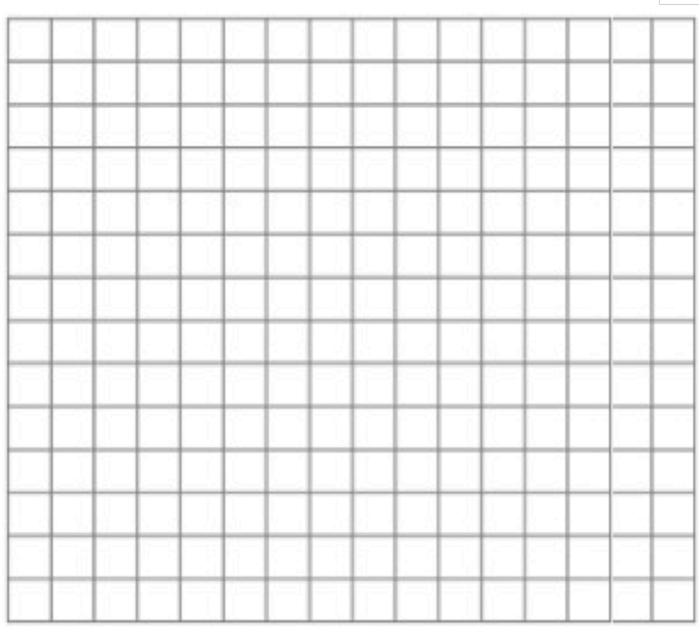
Graphical Analysis of Vectors

1. Add vectors by placing the tail of one vector at the head of the other vector.

2. A third vector is drawn connecting the tail of the first vector with the tip of the last vector. This vector, the resultant, represents the sum of the vectors.

3. Order of addition does not matter.

Vector Addition in 1 Dimension



Ex.1 A = 8.0 m, E
B = 6.0 m, E

Ex 2. A = 8.0 m, E
B = 6.0 m, W

Ex.3 A = 8.0 m, W
B = 6.0 m, E

Vector Addition in 2 Dimensions

Ex. 1 A = 8.0 m E
B = 6,0 m, N

Resultant

a) magnitude = measure the length from tail of the 1st vector to the tip of the last vector.

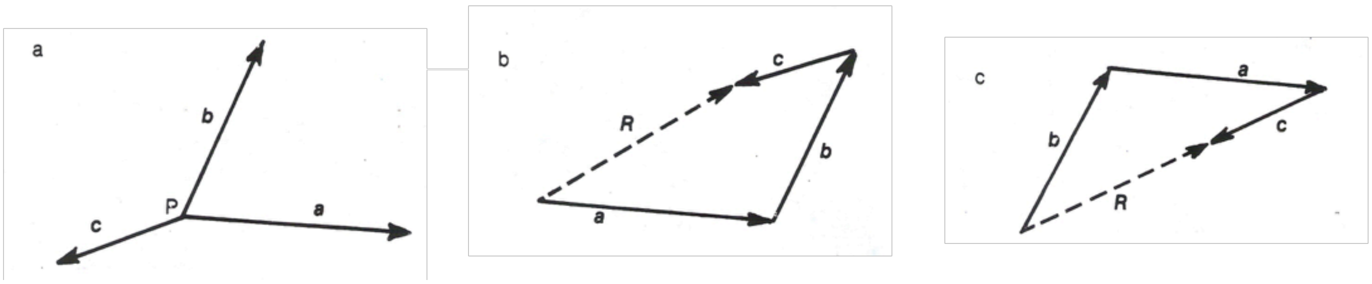
b) direction = measure the angle with a protractor from the horizontal vector, measured counterclockwise.

Several Vectors

1. A hiker travels 7 km N, then 4 km E and 3 km S. What is the hiker's final displacement?

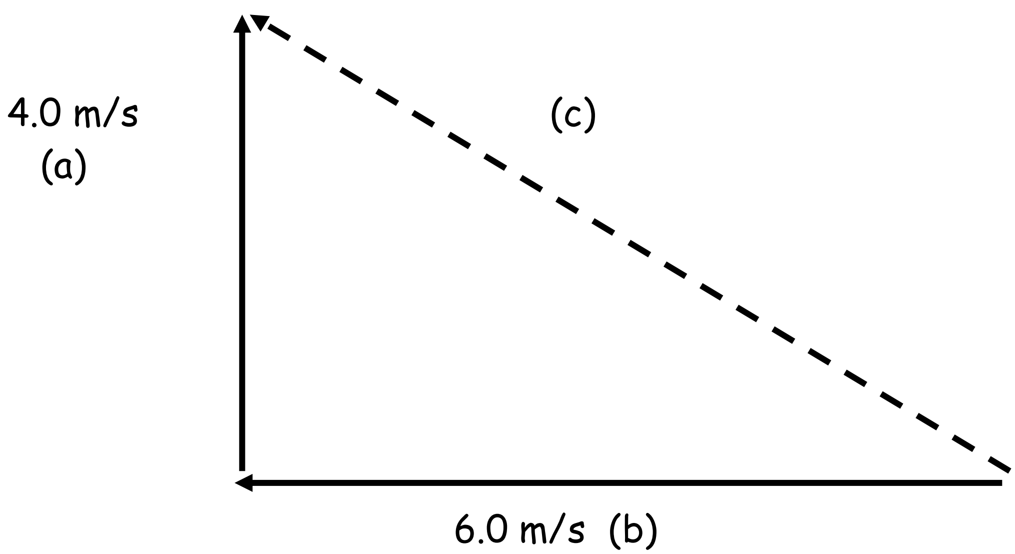
VECTOR ADDITION:

Order of addition does not matter – the resultant still has the same magnitude and direction!



Analytical Method of Vector Addition

Length of the Vector: Pythagorus Theorum



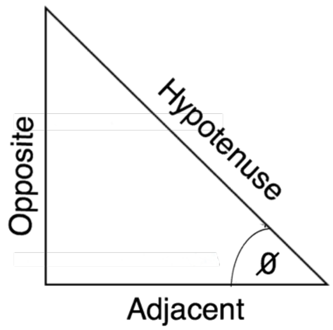
$a^2 + b^2 = c^2$

$4.0^2 + 6.0^2 = c^2$

$C = \sqrt{(4.0^2 + 6.0^2)}$

$= 7.2$ m/s

Angle of the Vector: Trigonometric Functions



$$\sin Ø = \frac{\text{opposite}}{\text{hypotenuse}}$$

$$\cos Ø = \frac{\text{adjacent}}{\text{hypotenuse}}$$

$$\tan Ø = \frac{\text{opposite}}{\text{adjacent}}$$

Remember: SOH/CAH/TOA

Ex#1: An airplane flying toward 0° at 90 km/h is being blown toward 90° at 50 km/h. What is the resultant velocity of the plane?

Ex#2. A swimmer jumps into a river and swims straight for the other side at 3.0 km/h (N). There is a current in the river of 4 km/h (W). What is the swimmers velocity relative to the shore?

Vector Addition

1. If a vector that is 1 cm long represents a displacement of 5 m, how many metres does a vector 3 cm long, drawn to the same scale, represent?

2. A vector drawn 15 mm long represents a velocity of 30 m/s. How long should you draw a vector to represent a velocity of 20 m/s?

3. An airplane normally flies at 200 km/h. What is the resultant velocity of the airplane if:
   a) it experiences a 50 km/h tail wind?

   b) it experiences a 50 km/h head wind?

4. Find the final displacement when the following vectors are added:
   a) 10 m E and 20 m W
   c) 10 m E and 20 m S

   b) 10 m E and 20 m N
   d) 10 m W and 20 m E

5. After walking 11 km due north from camp, a hiker then walks 11 km due east.
   a) What is the total distance walked by the hiker?

   b) Determine the total displacement from the starting point.

6. An explorer walks 13 km due east, then 18 km north, and finally 3 km west.
   a) What is the total distance walked?

   b) What is the resulting displacement of the explorer from the starting point?

7. A hiker leaves camp and, using a compass, walks 4 km E, 6 km S, 3km E, 5 km N, 10 km W, 8 km N, and 3 km S. At the end of three days, the hiker is lost. By drawing a diagram, compute how far the hiker is from camp and which direction should be taken to get back to camp.

8. You head down a river in a canoe. You paddle at 5.0 km/h and the river is flowing at 2.0 km/h. What is your resultant velocity? (Give both magnitude and direction).

9. CHALLENGE: Kyle wishes to drive his boat across a river to a point 4.5 km due south in 12 minutes. The river is flowing westward with a current of 5.0 km/h.. Compute the proper heading and speed that Kyle must choose in order to reach his destination on time.

Independence of Perpendicular Velocity Vectors

- perpendicular vector quantities are independent of each other; if I change my velocity in the north-south direction, it does NOT affect my velocity in the east-west direction.

Ex#1: A motorboat heads east at 8.0 m/s across a river that flows north at 5.0 m/s.

a) Calculate the resultant velocity

b) If it takes the boat 10 s to cross the river, what is the width of the river.

c) How far down the river did he travel?

Ex#2. A boat travels 3.5 m/s and heads straight across a river that is 240m wide.

a) if the river flows at 1.5 m/s, what is the resultant speed of the boat relative to the shore?

b) How long does it take the boat to cross the river?

Independence of Vectors

1. A speedboat travels at 8.5 m/s. It head straight across a river 110 m wide.
   a) If the water flows downstream at a rate of 3.8 m/s, what is the boat's resultant velocity?

   b) How long does it take the boat to reach the opposite shore?

2. A motorboat heads due east at 16 m/s across a river that flows due north at 9.0 m/s.
   a) What is the resultant velocity (speed and direction) of the boat?

   b) If the river is 136 m wide, how long does it take the motorboat to reach the other side?

   c) How far downstream is the boat when it reaches the other side of the river?

3. Paul swims due east at a rate of 3.0 km/h, while the river he is crossing flows south at 1.5 km/h.
   a) What is Paul's resultant velocity?

   b) If it takes Paul 20.0 minutes to cross the river, how wide is it?

   c) How far downstream will Paul reach the other side?

4. CHALLENGE: A pilot wants to fly to a city that is 500 km due west of his current position. The wind is blowing towards the north at 50 km/h. The maximum air speed of the airplane is 350 km/h.

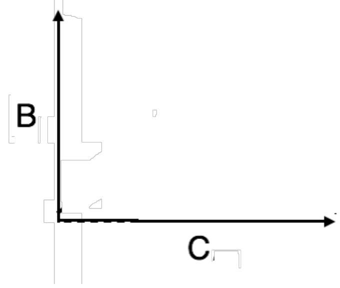
   a) What direction should the pilot fly in to reach the city?

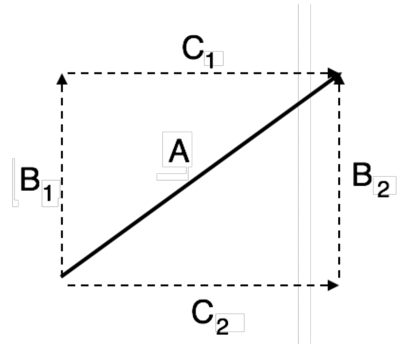
   b) How long will it take the plane to reach its destination?

Components of Vectors

- 2 vectors acting in different directions may be replaced by a single vector the **resultant**.

Therefore:
- a single vector is the resultant of 2 vectors.





A is a result of B and C.

Vector Resolution - finding the magnitude of a component in a given direction.

Ex#1. A person pulling a sled exerts a force of 58N on a rope held at an angle of 30° with the horizontal. What is the vertical component? What is the horizontal component?

Ex#2. A wind with a velocity of 40.0 km/h blows towards 30.0°.
a) What is the component of the winds velocity toward 90.0°?

b) What is the component of the winds velocity toward 0°?

Ex#3. Beth attempts to pull a stake out of the ground by pulling a rope that is attached to the stake. The rope makes and angle of 60.0° with the horizontal. Beth exerts a force of 125N on the rope. What is the magnitude of the vertical component of the force acting on the stake.

Components of Vectors

1. A wind with a velocity of 40.0 km/h blows towards N50.0°E.

   a) What is the component of the wind's velocity towards the north?

   b) What is the component of the wind's velocity towards the east?

2. A hiker walks 14.7 km at an angle of 305° from east. Find the east-west and north-south components of this walk.

3. A boat travels at a velocity of 25 km/h at a heading of N45°E. The river is 1500 m wide and flows due north.
   a) How long does it take the boat to cross the river?

   b) How far downstream will the boat hit the other shore?

Projectile Motion

Projectiles - an object that is_________.
ie. thrown baseball, kicked football, speeding bullet.

Trajectory - the __________ of a projectile.

Objects Launched Vertically

If an object is thrown upwards:

- the initial vertical velocity will be have a ___________ magnitude.
- The vertical velocity at the top of the trajectory will by ________.
- The time it takes to get to the top of the trajectory is equal to ______ the time of the total trajectory.

Example: A ball is thrown straight upwards with a (initial) vertical velocity of +12 m/s.

a) How high does the ball go?

b) What is the ball's final velocity if it is caught at the same height it was thrown? How does it compare to the initial velocity?

c) How long is the ball in the air?

Vertical Projectiles Practice

1. A penny is thrown upwards with an initial velocity of 4.2 m/s. How high does the penny go?

2. A water balloon thrown upwards is in the air for 2.5 seconds.
   a. How high did the balloon go?

   b. With what velocity was the balloon originally thrown?

3. A rocket shot straight upwards reaches a maximum height 150 m. How long is the rocket in the air for?

4. A pencil is thrown upwards towards the ceiling that is 2.1 m above a student's desk. What is the minimum velocity that the pencil would need to be thrown if it is to stick in the ceiling?

1. 0.90 m; 2. a) 7.7 m; b) +12 m/s; 3. 11s; 4. 6.4 m/s

Objects Launched Horizontally

The vertical and horizontal velocities of a projectile are __________ of each other.

2 cannon balls:

B - launched horizontally at 20.0 m/s

A - dropped from the same height

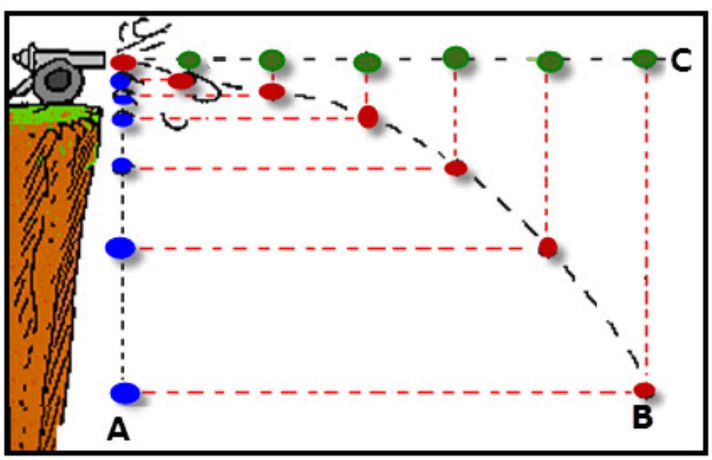
- A has a constant horizontal velocity of ______. A falls at _____ m/s^2

- B moves horizontally at a ________________ velocity of 20.0 m/s.

  (Newton's 1st Law - Inertia).

- B also falls at ________ m/s^2

- Both fall at the ________ rate and hit the ground at the same ________.



The horizontal velocity is __________. The vertical velocity is changing due to __________.

Ex#1: A stone is thrown horizontally at a speed of 5.0 m/s from the top of a cliff 78.4 m high.

b) How long does it take the stone to strike the ground?

c) How far from the base of the cliff does the stone strike the ground?

d) What is the stones vertical velocity when it hits the ground?

Ex#2: Thelma and Louise drive off a cliff 400m high, travelling at 72**km/h**.

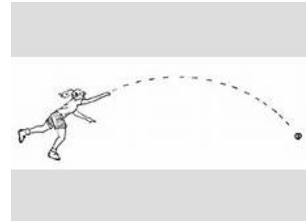
a) How long does it take to hit the ground?

b) How far from the base of the cliff does it hit the ground?

c) What is it's vertical velocity when it hits the ground?

Projectiles Practice

1. Consider the ball's trajectory .
   a. Where is the ball travelling the fastest in the vertical direction?



   b. Where is the ball moving the slowest in the vertical direction?

   c. Where is the horizontal velocity the greatest?

2. An airplane pilot flying at constant velocity and altitude drops a flare. Ignoring air resistance, where will the plane be relative to the flare when the flare hits the ground?

3. A zoologist standing on a cliff aims a tranquilizer gun at a monkey hanging from a distant tree branch. The barrel of the gun is horizontal. Just as the zoologist pulls the trigger, the monkey lets go of the branch and begins to fall. Will the dart hit the monkey?

4. A stone is thrown horizontally at a speed of +5.0 m/s from the top of a cliff 78.4 m high.
   a. How long does it take the stone to reach the bottom of the cliff?

   b. How far from the base of the cliff does the stone strike the ground?

   c. What are the horizontal and vertical components of the velocity of the stone just before it hits the ground?

5. How would the three answers to Question #4 change if:
   a. The stone was thrown with twice the horizontal speed

   b. The stone was thrown with the same speed but the cliff was twice as high?

6. A dart player throws a dart horizontally at a speed of 12.4 m/s. The dart hits the board 0.32 m below the height from which it was thrown. How far away is the player from the board?

7. An automobile, moving too fast on a horizontal stretch of mountain road, slides off the road, falling into deep snow 43.9 m below the road and 87.7 m beyond the edge of the road.
   a. How long did the auto take to fall?

   b. How fast was it going when it left the road?

   c. What was the acceleration 10 m below the edge of the road?

1. a) At the end; b) at the top of the trajectory; c) same throughout 2. Directly overhead 3. Yes 4.a) 4.00 s; b) 20 m; c) v_x = 5.0 m/s; v_y= -39.2 m/s 5a) no change to time or vertical component of v_f; horizontal distance and horizontal v_f doubles, b) time, vertical v_f and horizontal distance increase; 6. 3.2m 7. a) 2.99 s; b) 29.3 m/s; c) -9.81 m/s^2

Chapter 6: Work and Mechanical Energy

Energy is the capacity to do __________

Work

- the product of _______exerted on an object and the ________the object moves in the _______________ of the force.

W=Fd

W = ______(Joules, J)
F = _______ applied (N)
d = ______________(m)

- If a __________force is applied with no__________, then ______ work is done.
- If a force is exerted _____________ to the motion, then no ______ is done.
- If a force is exerted at an _________ to the motion, then the force can be replaced by its_________. Only the component in the __________of motion does work.

Ex#1: How much work do you do when you climb a 3.0 m high staircase? (Assume your weight is 600 N)

Ex 2: A man pulls a toboggan along the snow with the rope at an angle of 40.0° with the horizontal. How much work is done by the man if he exerts a force of 255 N on the rope and pulls the toboggan 30.0 m?

Work

1. When a bowling ball rolls down a level alley, does Earth's gravity do any work on the ball? Explain.

2. A force of 825 N is needed to push a car across a lot. Two students push the car 35 m.
    a. How much work is done?
    b. After a rainstorm, the force needed to push the car doubled because the ground became soft. By what amount does the work done by the students change?

3. A delivery clerk carries a 34 N package from the ground to the fifth floor of an office building, a total of 15 m. How much work is done by the clerk?

4. What work is done by a forklift raising a 583 N box to a height of 1.2 m?

5. You and a friend each carry identical boxes to a room one floor above you and down the hall. You choose to carry it first up the stairs and then down the hall. Your friend carries it down the hall, and then up another stairwell. Who does more work?

6. How much work does the force of gravity do when a 25N object falls a distance of 3.5 m?

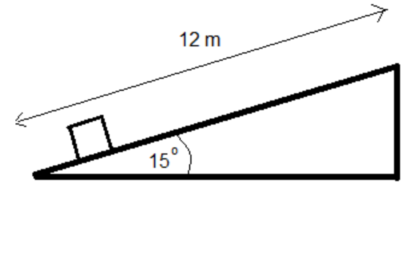
7. An airplane passenger carries a 215 N suitcase up stairs, a displacement of 4.20 m vertically and 4.60 m horizontally.
   a. How much work does the passenger do?

   b. The same passenger carried the same suitcase back down the same stairs. How much work does the passenger do now?

8. A rope is used to pull a metal box 15.0 m across the floor. The rope is held at an angle of 46.0° with the floor and a force of 628 N is used. How much work does the force on the rope do?

9. A sailor pulls a boat along a dock using a rope at an angle of 60.0° with the horizontal. How much work is done by the sailor if he exerts a force of 255 N on the rope and pulls the boat 30.0 m?

10. Ronan pushes a 5.0 kg box up a 12 m long ramp that is built at a 15° angle to the horizontal. How much work does Ronan do?



Answers: 1) No – displacement is perpendicular to force 2a) 2,9x10^{4}J b) doubles 3) 510J 4) 7.0x10^{2}J 5) same 6) 88J
7a) 903J b) -903J 8) 6.54x10^{3}J 9) 3,83x10^{3}J 10) 1.5x10^{2}J

Mechanical Advantage

- Simple ____________ such as pulleys, ramps and levers can be used to help people do work.
- The amount of _______ done doesn't change, only the amount of effort (force) required to get it done!
- If the work doesn't change, but the effort force goes down, then that force MUST be applied over a greater _____________

- Mechanical advantage is the amount of _______ you get by using the machine (rather than just doing that work directly).

$$\text{Mechanical Advantage} = \frac{\text{Load Force}}{\text{Effort Force}}$$

Ex#1: A set of pulleys is used to lift a 722 kg car engine. If a 295 N force is needed to lift the engine, what is the mechanical advantage of the set of pulleys?

Ex#2: Beth needs to bring a 52 kg box of books up a 3.0 m high flight of stairs. Instead of carrying them directly up, she sets up a 12 m ramp. If Beth needs to apply a force of 150 N to push the box up the ramp, what is the mechanical advantage of the ramp?

Power

- ______ at which work is done.

$$P = \frac{W}{t}$$

P =______, watts (w)
W =______, Joules (J)
t =_____, seconds (s)

Ex#1: How much power is developed by a 70.0 kg boy running up a flight of stairs, 4.5 m high in a time of 2.5 s?

Ex#2: How much energy (or work!) does a 1500 W toaster convert to heat in 2 minutes?

Power

1. A box that weighs 575 N is lifted a distance of 20.0 m straight up by a rope. The job is done in 10.0 s. What power is developed?

2. A rock climber wears a 7.50 kg knapsack while scaling a cliff. After 30.0 min, the climber is 8.2 m above the starting point.
   a. How much work does the climber do on the knapsack?

   b. If the climber weighs 645 N, how much work does she do lifting herself and the knapsack?

   c. What is the power developed by the climber?

3. Brutus, a champion weightlifter, raises 240 kg a distance of 2.35 m.
   a. How much work is done by Brutus lifting the weights?

   b. How much work is done holding the weights above his head?

   c. How much work is done lowering them back to the ground?

   d. If Brutus completes the lift in 2.5 s, how much power is developed?

4. An electric motor develops 65 kW of power as it lifts a loaded elevator 17.5 m in 35.0 s. How much force does the motor exert?

5. A horizontal force of 805 N is needed to drag a crate across a horizontal floor with a constant speed. Pete drags the crate using a rope held at an angle of 32°.
   a. What force does Pete exert on the rope?

   b. How much work does Pete do on the crate when moving it 22 m?

   c. If Pete completes the job in 8.0 s, what power is developed?

6. Seth pulls a 305 N sled along a snowy path using a rope that makes a 45.0° angle with the ground. Seth pulls with a force of 42.3 N. The sled moves 16 m in 3.0 s. What is Seth's power?

ANSWERS: 1) 1.15×10^3W 2a) 6.0×10^2J b) 5.9×10^3J c) 3.3W 3a) 5.5×10^3J b) no work c) -5.5×10^3J d) 2.2×10^3W 4) 1.3×10^5N 5a) 949N b) 1.8×10^4J c) 2.3×10^3W 6) 1.6×10^2W

Mechanical Energy

Energy: the ability to do ________

transfer of energy = _______ done on an object

$$\Delta E = W$$

Forms of Mechanical Energy

__________ Energy - as a result of an object's ________.
ie. roller coaster at the top of a hill

__________ Energy - due to the _______ of an object. ie. moving car

Gravitational Potential Energy

- dependent on the object's _________ above the Earth's surface.

$$W = F.d$$

since $F_g =$

and $d =$

then, $\mathbf{E_p = mgh}$

E_p = __________________ (J)

m = __________________ (kg)

g = __________________ (9.80 m/s^2)

h = __________________ (m)

- formula is valid only where g is ________.
- select a position at which an object's ____________ is zero (lowest point)
- potential energy is measured relative to the ______________.

Ex#1: Each step of a ladder increases one's vertical height by 40cm. If a 90.0 kg painter climbs eight steps of the ladder, what is the increase in potential energy?

Ex#2: A 10.0 kg rock is on top of a house 3.00 m high on the edge of a cliff that is 20.0 m high. What is the gravitational potential energy of the rock…

a) relative to the roof of the house? ___________________

b) relative to the floor of the house? ___________________

c) relative to the bottom of the cliff? __________________

Kinetic Energy

- result of ________ being done on an object.
- depends on an object's _______ and ___________.

Work done is	W= F.d
Since	F = ma
then,	W = mad
If $v_f^2 = v_i^2 + 2ad$ then	$ad = v_f^2 - v_i^2$
If an object starts at rest,	$ad = v_f^2/2$
	$W = m (v_f^2/2)$

THEREFORE : $E_K = \frac{1}{2} mv^2$

E_k = ______________ (J)

m = ____________ (kg)

v = ____________ (m/s)

Ex#1: What is the kinetic energy of a 25.0 g bullet travelling at 3600 km/h?

Work - Energy Theorem

$$W = E_{Kf} - E_{Ki} = \Delta E_K$$

$$\Delta E_K = \tfrac{1}{2} mv_f^2 - \tfrac{1}{2} mv_i^2 = \tfrac{1}{2} m (v_f^2 - v_i^2)$$

" The net work done on an object is equal to its _____ in Kinetic Energy."

Net work is _______ if net force acts in the _______ direction as the motion, and kinetic energy ___________.

Net work is _______ if net force acts in the ________ direction of the motion, and kinetic energy ___________.

Ex#1. How much work does a pitcher do when he accelerates a 145g baseball from rest to 25 m/s?

Ex#2. A car gains 577 KJ of kinetic energy when it accelerates from 12 m/s to 25 m/s in 12 seconds. What is the mass of the car?

Conservation of Energy

"Within a closed, isolated system, energy can _______ form, but the total amount of energy is _________."

- Energy can be neither ________ nor __________.

Mathematically:

$$E_{Ki} + E_{Pi} = E_{Kf} + E_{Pf}$$

Total energy _______ = Total energy __________

The decrease in potential energy is equal to the increase in its kinetic energy.

$$\Delta E_k = \Delta E_p$$

The total energy, E, of an object is the sum of the kinetic energy and potential energy

$$E = E_k + E_p$$

E**x#1**: A 20.0 kg rock falls 50 m from rest.

a) What is the rock's loss in gravitational energy?

b) What is its gain in kinetic energy? _________

c) What is the final speed of the rock?

Ex#2: A girl on a bicycle is on the top of a 15 m high hill. How fast will she be moving at the bottom of the hill? (Ignore friction)

Kinetic Energy

1. A compact car has a mass of 750 kg.
   a. Calculate the kinetic energy of the car moving at 50 km/h.

   b. How much work must be done on the car to slow it from 100 km/h to 50 km/h?

   c. How much work must be done on the car to bring it from 50 km/h to rest?

   d. The force that does the work is constant. Find the ratio of the distance needed to slow the car from 100 km/h to 50 km/h to the distance needed to slow it from 50 km/h to rest.

2. A rifle can shoot a 4.20 g bullet at a speed of 965 m/s.
   a. Find the kinetic energy of the bullet.

   b. What work is done on the bullet if it starts from rest?

   c. If the work is done over a distance of 0.75 m, what is the average force on the bullet?

   d. If the bullet comes to rest by pushing 1.5 cm into metal, what is the average force it exerts?

3. A comet with mass 7.85×10^{11} kg strikes Earth at a speed, relative to Earth, or 25 km/s. Find the kinetic energy of the comet in joules.

4. A 5700 kg trailer truck needs 2.2×10^{6} J of work to accelerate it to 100 km/h.
   a. How fast would it go if just half as much work is done on it?

   b. How fast would it go if twice as much work is done on it?

Potential Energy

5. A 90 kg rock climber first climbs 45 m upward to the top edge of a quarry, then, from the top, descends 85 m to the bottom. Find the potential energy of the climber at the edge and at the bottom, using the initial height as the reference level.

6. A 50.0 kg shell is shot from a cannon at Earth's surface to a height of 4.00×10^2 m.
    a. What is the gravitational potential energy with respect the Earth's surface of the Earth-shell system when the shell is at this height?

    b. What is the change in potential energy of the system when the shell falls to a height of 2.00×10^2 m?

7. A person weighing 630 N climbs up a ladder to a height of 5.0 m.
    a. What work does the person do?

    b. What is the increase in the gravitational potential energy of the person from the ground to this height?

    c. Where does the energy come from to cause this increase in the gravitational potential energy?

8. A pendulum is constructed from a 7.26 kg bowling ball hanging on a 2.5 m long rope. The ball is pulled back until the rope makes a 45^0 angle with the vertical.
    a. What is the potential energy of the ball?

    b. What reference level did you use in your calculations?

Conservation of Energy

9. A bike rider approaches a hill at 8.5 m/s. The total mass of the bike and rider is 85 kg.
    a. Find the kinetic energy of the bike and rider.

    b. The rider coasts up the hill. Assuming there is no friction, at what height will the bike come to a stop?

10. Tarzan, mass 85 kg, swings down from a tree limb on the end of a 20 m vine. His feet touch the ground 4.0 m below the limb.
    a. How fast is Tarzan moving when he reaches the ground?

    b. Does your answer depend on Tarzan's mass?

    c. Does your answer depend on the length of the vine?

11. A skier starts from rest at the top of a 45 m hill, skis down a 30° incline into a valley, and continues up a 40 m hill. Both hill heights are measured from the valley floor. Assume you can neglect friction and the effect of ski poles.
    a. How fast is the skier moving at the bottom of the hill?

    b. What is the skier's speed at the top of the next hill?

1.a) 7.4×10^4J; b) -2.20×10^5J; c) -7.4×10^4J; d) 3:1 2. a) 1.96×10^3 J; b) 1.96×10^3 J; c) 2.6×10^3 N; d) -1.3×10^5 N 3. 2.5×10^{20} J; 4. a) 71km/h; b) 140 km/h; 5. $+4.0\times10^4$J; -3.5×10^4J; 6. a) 1.96×10^5J; b) -9.80×10^4J; 7. a) 3200 J; b) 3200 J; c) work done on person; chemical energy stored in person's body; 8. a) 52J; b) height of ball when rope was vertical; 9. a) 3.1×10^3J; b) 3.7 m; 10. a) 8.9 m/s; b) no; c) no; 11. a) 30m/s; b) 10 m/s

Energy Concept Review

1. Describe the work done and the energy changes taking place when:
    a. You climb a rope.

    b. You throw a ball horizontally

    c. A horizontally thrown ball is caught in a mitt

    d. A horizontally thrown ball falls, gaining vertical velocity

2. A student is doing a problem involving a ball falling down a well. If the top of the well is chosen as the reference level for potential energy, then what is the sign of the potential energy at the bottom of the well?

3. Explain how energy and work are related.

4. Explain how energy and force are related.

5. Can the kinetic energy of a baseball ever have a negative value? Explain.

6. Sally and Lisa have identical compact cars. Sally is northbound on the freeway and Lisa is southbound with the same speed. Which car has more kinetic energy?

7. If you drop a tennis ball onto a concrete floor, it will bounce back farther than if you drop it on a rug. Where does the lost energy go when it strikes the rug?

8. If two identical bowling balls are raised to the same height, one on the Earth, and the other on the moon, which has the larger potential energy relative to the surface of the bodies?

Chapter 7 Thermal Energy

Thermodynamics – the study of ___________

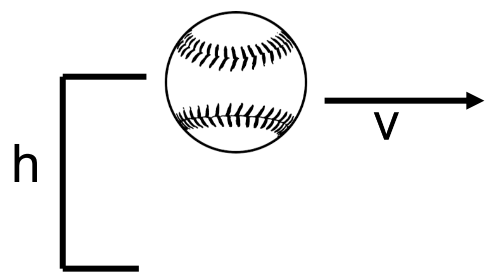
Kinetic Molecular Theory

- all matter is made up of particles in constant ___________.
- a hotter body has ___________ moving particles than a cooler body, thus more ___________.

External Energy of a Baseball

- result of ___________ and ___________ of a baseball.

$E_p = mgh$



$E_k = \frac{1}{2} mv^2$

Internal Energy of a Baseball

- result of the ___ and ___ of the particles
- E_k of particles = particles ___________ back and forth.
- E_p of particles = ___________ of particles due to electromagnetic forces.
- Thermal Energy - the _____ of the E_k and E_p energy of the ___________ motion of particles that make up an object.

Thermal Energy vs. Temperature

Thermal Energy – the __________ kinetic energy of all particles of an object; **Temperature** - the ___________ kinetic energy of the particles of an object; measured with a ____________.

- particles of an object have a ______ of energies, some high and some low.

- hotter objects have great___________ E_k of particles.

Heat

Heat - the amount of ________ energy transferred from one object to another due to differences in _______________ between the objects.

Equilibrium – occurs when the rate of energy __________ between two bodies is ________; objects at equilibrium are at the same _________.

Thermal Energy Transfer

conduction - transfer of kinetic energy in __________ when particles of an object __________.

convection - heat transfer by the movement of __________ caused by different __________.

radiation - transfer of thermal energy through __________ in the of __________ waves (i.e., infrared)

Temperature Scales

- **thermometer** - device used to measure __________. It is placed in contact with an object and allowed to come to thermal __________.

Celcius

- scale based on the properties of __________.

Kelvin

- scale based on _____________, no upper limit.
- used to accommodate wide range of temperatures in the __________.
- absolute zero – temperature at which all _____________is removed from objects. (-273.15°C)

Celsius	Kelvin
-273.15 °C	
0.00 °C	
22.00 °C	
100.00 °C	

5.4 Measuring Heat Energy

- energy transferred as a result of a difference in temperature.
- dependent on:

  a) __________of the object,
  b) __________ in temperature,
  c) __________________ of material.

$$Q = m \cdot C \cdot \Delta T$$

Q = heat energy gained or lost (J) (sometimes E_h)
m = mass (kg)
C = specific heat (J/Kg°C or J/Kg.K)
ΔT = change in temperature (°C or K)

Ex#1: A 0.4 kg block of iron is heated from 295 K to 325 K. How much heat is absorbed by the iron? (See table on pg. 121 of workbook for values of C)

Ex#2: After 250 kJ of heat is transferred to a container of water, the temperature rose to from 15°C to 25 °C. What was the mass of the water in the container?

Thermal Energy

Concept Questions

1. Explain the difference between a ball's external energy and its thermal energy.

2. Explain the difference between a ball's thermal energy and temperature.

3. Can temperature be assigned to a vacuum? Explain.

4. Do all of the molecules or atoms in a liquid have about the same speed?

5. Could the thermal energy of a bowl of hot water equal that of a bowl of cold water? Explain.

6. On cold winter nights before central heating, people often placed hot water bottles in their beds. Why would this be better than, say, warmed bricks?

7. If you take a spoon out of a cup of hot coffee and put it in your mouth, you won't burn your tongue. But, you could very easily burn your tongue if you put the liquid in your mouth. Why?

Problems:

1. Convert these Celsius temperatures to Kelvin temperatures.
   - a. 0°C
   - b. 273 °C
   - c. 27°C
   - d. 560°C
   - e. -184°C
   - f. -300 °C
2. Covert these Kelvin temperatures to Celsius temperatures.
   - a. 0K
   - b. 273K
   - c. 110K
   - d. 22K
   - e. 402K
   - f. 323 K

1: 273K; 546K; 300K; 833K; 89K; impossible; 2: -273°C; 0°C; -163°C; -251°C; 129°C; 50°C

3. How much heat is absorbed by 60.0 g of copper when it is heated from 20.0°C to 80.0°C?

($1.39x10^3$J)

4. A 38 kg block of lead is heated from -26 °C to 180 °C. How much heat does it absorb during the heating? ($1.0x10^6$J)

5. The cooling system of a car engine contains 20.0 L of water (1 L of water has a mass of 1kg). What is the change in the temperature of the water if the engine operates until 836.0 kJ of heat are added? (10.0°C)

6. A $5.00x10^2$ g block of metal absorbs 5016 J of heat when its temperature changes from 20.0°C to 30.0°C. Calculate the specific heat of the metal. ($1.00x10^3$ J/kgK)

7. A 565g cube of iron is cooled from the temperature of boiling water to room temperature (20°C).
   a. How much heat must be absorbed by the cube? ($2.0x10^4$ J)
   b. If the iron is cooled by dunking it into water at 0°C that rises in temperature to 20°C, how much water is needed? (0.24kg)

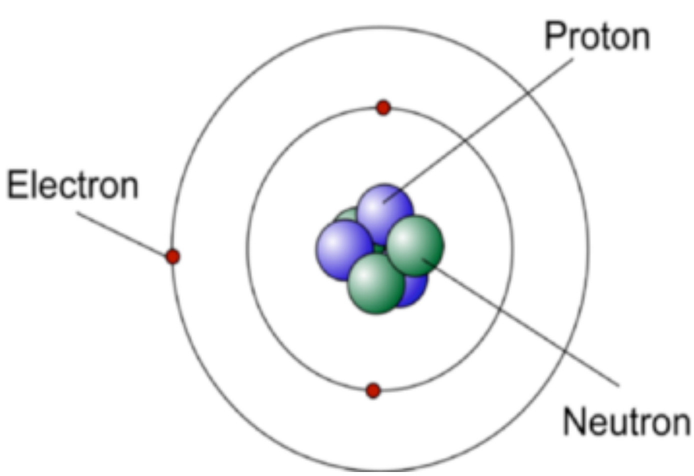
Chapter 8: Static Electricity

6.1 Electrical Structure of Matter

Bohr-Rutherford Model:

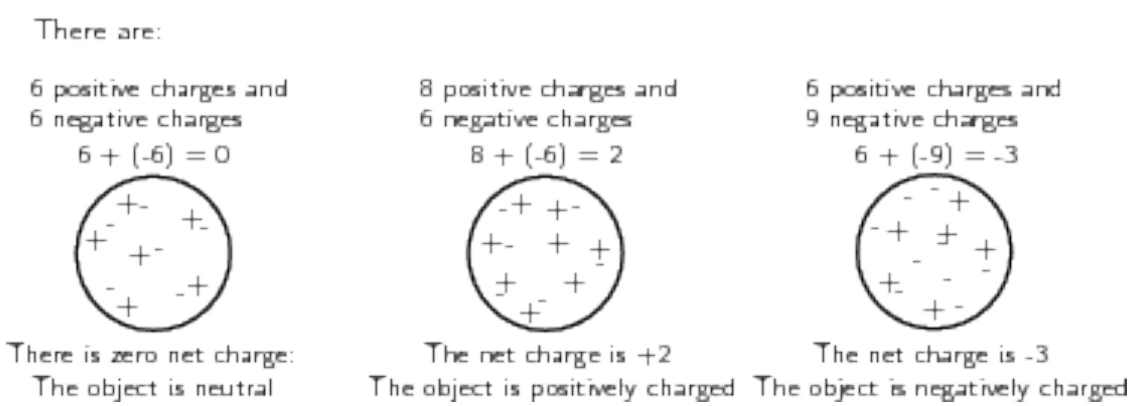
- Matter is composed of particles called ________
  - Protons:
    - found in the ___________
    - small, _________ particles
    - ______________ charged
  - Electrons:
    - Move in the space __________ the nucleus
    - Small and ________ (about 1/2000th mass of a proton)
    - __________ charged
  - Neutrons:
    - Found in __________
    - Small __________ particles
    - Do not carry a __________

- Atoms are normally electrically __________ – equal number of protons and electrons



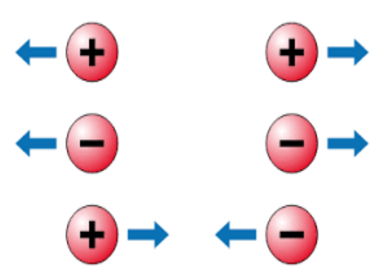
Electrostatics

- Atoms of a __________ are held in place
- Nuclei __________ but are not free to move, therefore the positive charge remains fixed
- Outermost __________ can move from atom to atom, causing charges to form.
- Whenever electrons are added or removed from a solid, it becomes __________
    - When electrons are removed – object becomes __________ charged
    - When electrons are added – object becomes ____________ charged



Rules of Static Charge

- Objects with like charges __________ each other
- Objects with unlike charges __________ one another
- Charged objects __________ neutral objects



Law of Conservation of Charge

- the ________ charge of an isolated system remains constant
- Charge is '_________', meaning that charge comes in integer multiples of the elementary charge, e
  - A _________ has a charge of +e, while the _________ has a charge of –e.
- In the early 20th century, R. Millikan found the smallest unit of charge:

  $e = 1.60 \times 10^{-19}$ C where C is the unit of charge, _________

  or

  $1\ C = 6.24 \times 10^{18}$ e.

- The charge on an object, then can be calculated by using the formula:

  $Q = Ne$

  where Q = electric _________

  N = _________ number of electrons or protons

  e = charge of a single proton or electron (1.6×10^{-19} C)

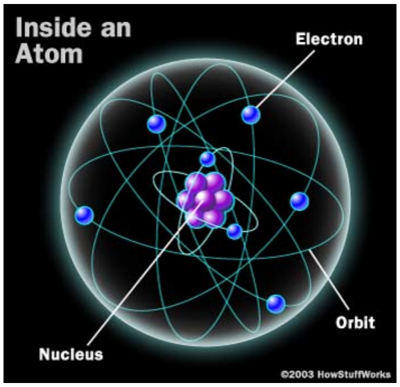
Ex. 1 How many electrons have been removed from a positively charged pith ball electroscope if it has a charge of 7.5×10^{-11} C?

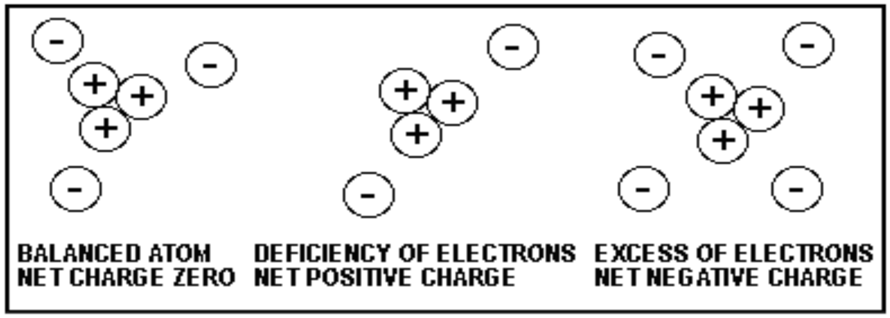
Ex. 2 What is the charge, in coulombs, on an object that has:

a) An excess of 6.25×10^{19} electrons?

b) A deficiency of 1.0×10^{8} electrons?

Electrostatics - Charging objects





There are two types of charges. They are positive and negative charges.

- Negative charges are created when electrons are added.
- Positive charges are created when electrons are lost.

The total charge on any object can be found by knowing the number of excess or deficient electrons on that object.

The charge of an electron is $e = -1.6 \times 10^{-19}C$.

The total charge on an object is given by **$Q = ne$**

where Q is the total charge in Coulombs, n is the number of electrons and e is the charge of an electron.

Protons have the same charge as the electrons. Except that they are positively charged.

1. We will NEVER TALK about PROTON motion. Explain why not?

____

2. A neutral metal plate loses some electrons. It is now _______________ (type of charge). This is because electrons that are lost have _______________ charge.

3. A pop-can rubbed with fur will be _______________ (Type of charge). This is because ____________ are added to it.

4. Find the charge on a metal plate that has 500 excess electrons.

5. Find the number of excess electrons on pith ball that has a charge of -1.2C.

6. An electroscope has a total of 2.0×10^6 electrons and 1.8×10^6 protons. What is the net charge on the electroscope?

7. One atom of Gold carries 79 protons in the nucleus. 79 electrons orbit this nucleus.

A. Determine the net charge on one atom of gold.

B. Determine the net charge of the 79 protons in the nucleus of this atom.

Answers: 1) Protons are fixed; 2) positive, negative 3) negative, electrons 4) -8.0×10^{-17}C 5) 7.5×10^{18} e 6) -3.2×10^{-14}C
7) a) 0 C b) 1.4×10^{-17}C

Electrostatic Charging

- Most objects are electrically neutral; they have equal amounts of __________ and __________ charge

- Solids in which charge flows freely are called _____________ (i.e., most metals)
    - Outermost electrons in the atoms are so __________ bound to their atoms that they are free to move around

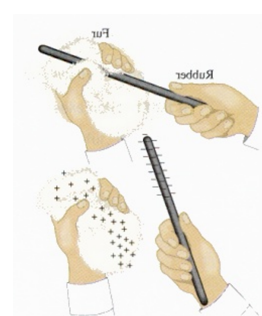
- Solids which __________ the flow of charge are called ____________ (plastic, cork, glass, wood, rubber)
    - Electrons are __________ bound to the atoms and are not free to flow

Charges can be transferred from one object to another through:

1) Friction:

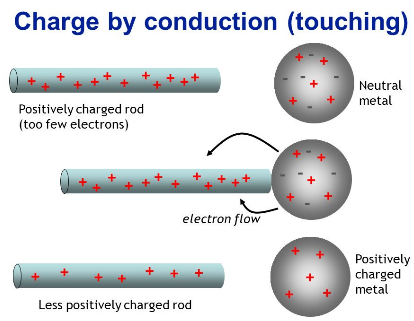
- If you rub one material with another, electrons have a tendency to be _____________ from one material to another

    Ex., glass with silk, PVC rod with fur



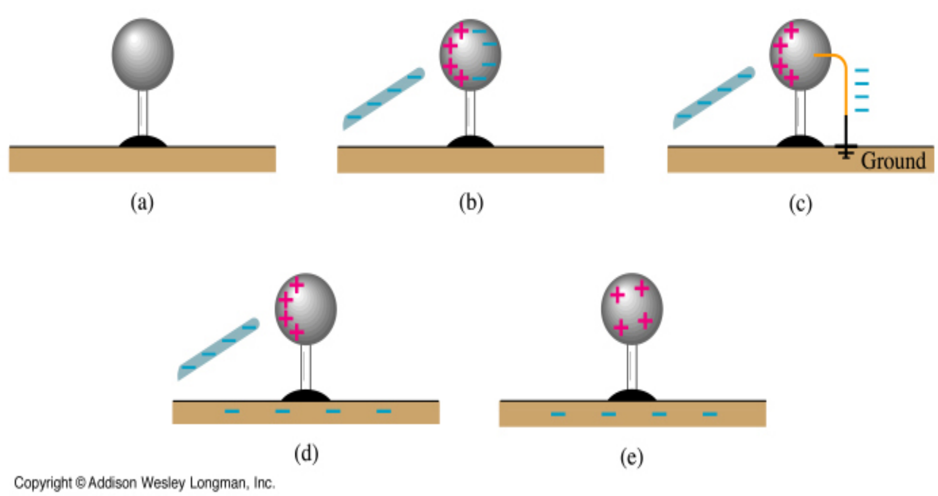
2) Conduction:

- If a charged object touches a conductor, some charge will __________ between the object and the conductor, __________ the charge with the conductor.



3) Induction

- charged object is brought close to the conductor, but does not touch.
- If the conductor is __________ (touching anything that can give up or take electrons), electrons will either flow _______ the conductor or ________ from it.
- When the ground connection is removed, the conductor will then have a charge __________ in sign to that of the charged object.



Electrostatics Concepts

1. What are the similarities and differences between the properties of an electron and a proton?

2. Describe the difference between a positively-charged object and a negatively-charged object, in terms of electrons.

3. Draw a diagram to show how an object can take on a negative charge using only a negatively-charged vinyl strip.

4. Draw a series of diagrams to show how an object can take on a positive charge using only a negatively-charged vinyl strip.

5. Why do clothes sometimes have static on them as soon as they come out of the clothes dryer?

6. A charged rod is brought near a pile of tiny plastic spheres. The spheres are attracted to the charged rod and then fly off the rod. Why does this happen?

7. The electrostatic series lists various objects according to how tightly they hold their electrons. What will be the charge on a silk scarf if it is rubbed with glass? With plastic wrap?

Hold electrons tightly
-
vinyl
plastic wrap
amber
cotton
paper
silk
fur
wool
glass
hands
+
Hold electrons loosely

8. Outline a method by which you could determine (with certainty) whether the charge on your comb after you comb your hair is positive or negative.

CHAPTER 6 REVIEW: STATIC ELECTRICITY

1. Describe what happens when the following charged objects interact:

Object #1	Object #2	Attract/Repel/Neither
+	+	
+	-	
+	0	
-	-	
-	0	
0	0	

2. Explain (in detail!) why a wooden metre stick will move towards a positively-charged acetate strip. Include a diagram in your explanation.

3. A vinyl strip is rubbed by a piece of fur, transferring electrons from the fur to the vinyl strip. You then touch a pop can lying on its side with the vinyl strip. If another charged vinyl strip is brought close to the can, what do you expect will happen?

4. Find the charge on a pith ball if it has 5.0×10^3 excess electrons.

8.0×10^{-16} C

5. Determine the net charge of a nitrogen nucleus (atomic number = 7).

1×10^{-18} C

Chapter 9: Current Electricity

Flow of Charge

- Charge can move from one object to another through a _________
- Electric current: when a charge moves, or '_________' from one place to another
- In metals, moving charges have a _________ charge:

I = Q/t   Q = _________ charge flowing past a point in a circuit

t = _________ over which charge flowed

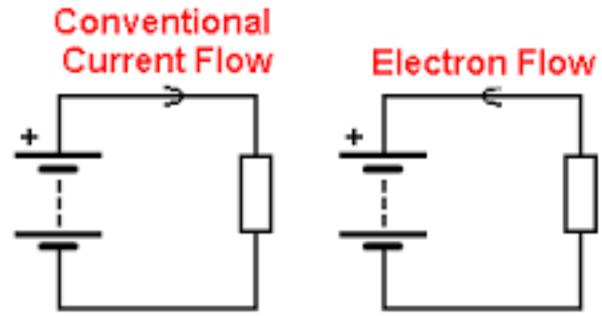
I = _________ (units: Amperes)

1 A = the electric current flowing when 1 C of charge moves past a point in a conductor in 1 s.

Ex.1: Calculate the current in an electric toaster if it takes 9.0×10^2 C of charge to toast 2 slices of bread in 1.5 min.

Ex. 2: A light bulb with a current of 0.80 A is left burning for 25 minutes. How much electric charge passes through the filament of the bulb?

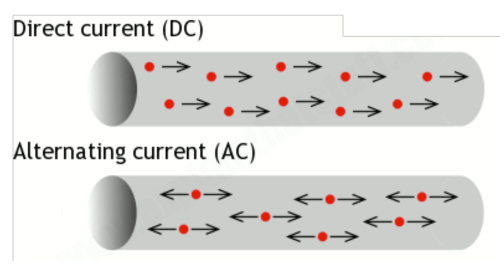
Conventional Current vs. Electron Flow



- Electric current is defined as the ________ of flow of electrically charged particles past a point
- Benjamin Franklin, in the 19th century, assumed that a __________ charge moved from an area where there was an excess of positive charges to an area where there was a __________ (a negative charge).
- Direction was therefore defined as moving from the positive terminal to the negative terminal of the source of potential energy. This is called ________________ current
- After this concept was firmly entrenched, the __________ was discovered and it became clear that an electric current is a flow of negatively-charged electrons from the negative terminal to the positive terminal – __________________.
- Unless told otherwise, assume that all diagrams use __________ current

Sources of Electric Current

- Electric current supplied by a __________ is significantly different from current supplied by a _______________
- Batteries supply __________ current (DC) – flow is in a fixed single direction with a constant magnitude
- Wall sockets supply ___________ current (AC) – flow periodically reverses direction in the circuit and the amount of current varies continuously.



Electric Charge and Current Worksheet

1. If there is a current of 10 amperes in a circuit for 10 minutes, what quantity of electric charge flows through the circuit?

2. How much current must there be in a circuit if 120 coulombs flow past a point in the circuit in 4.0 s?

3. How much time is required for 10.0 C of charge to flow past a point if the current is 2A?

4. In a lightning flash, a typical amount of charge which reaches the Earth is 10 C. If the flash lasts for 0.50 ms, what is the average current?

5. The current in a small flashlight is 0.20 A.

a. What is the total electric charge which passes a point in the circuit in 12 min?

b. How many electrons pass this point in this time?

6. Calculate the number of electrons passing a point in a wire in one minute, when the current is:
   a. 1.0 A

   b. 5.0 μA

7. A certain type of rechargeable battery is capable of delivering a current of 0.2 A for 4000s, before its voltage drops and it needs to be recharged. Calculate:
   a. The total charge the battery can deliver before it needs to be recharged.

   b. The maximum time it could be used without being recharged if the current through it was 0.5 A.

ANSWERS: 1) 6000C 2) 3.0×10^{1}A 3) 5s 4) 2×10^{4}A 5a) 1.4×19^{2}C b) 8.8×10^{20} e 6a) 3.8×10^{20} e b) $1,9 \times 10^{15}$ e 7a) 800C b) 2×10^{3}s

Electric Potential Difference (Voltage)

- Electrical potential energy – __________ energy as a result of electrical charges.
- Separating an electron from a proton requires __________, therefore increasing their stored energy (like stretching a spring).
- Charged particles __________ in the presence of an electric field and can __________ electrical potential energy into other forms of energy
- The __________ of energy results in an electric potential difference between two points
- Potential difference is measured in __________ (V), and is measured by a voltmeter:

1 volt = 1 joule/1 coulomb

ie., a 12 V car battery is a battery that does 12 J of work on each coulomb of charge that flows through it.

- The __________ done by a charge, Q, going through a potential difference, V, can be written as:

$$\Delta E = QV$$

Since $Q = I\Delta t$, then

$$\boxed{\Delta E = VI\Delta t}$$

Ex #1: A 12 V car battery supplies 1.0×10^3 C of charge to the starting motor. How much energy is used to start the car?

Ex #2: If a current of 10.0 A takes 3.0×10^2s to boil a kettle of water requiring 3.6×10^5 J of energy, what is the potential difference across the kettle?

Ex. #3: A 120 V electric sander operating for 5.0 min uses 1.0×10^5 J of energy. Find the current through the sander.

Electric Potential Difference Worksheet

1 What amount of energy does a kettle use to boil water if it has 810 C of charge passing through it with a potential difference of 120 V?

2 What is the potential difference across a refrigerator if 75C of charge transfers 9.0×10^{3}J of energy to the compressor motor?

3 An electric baseboard heater draws a current of 6.0 A and has a potential difference of 240V. For how long must it remain on to use 2.2×10^{5} J of electrical energy?

4 A flash of lightning transfers 2.0×10^{9} J of electrical energy through a potential difference of 7.0×10^{7} V between a cloud and the ground. Calculate the quantity of charge transferred in the lightning bolt.

5 Calculate the energy stored in a 9.0 V battery that can deliver a continuous current of 4.0mA for $2.0x10^3$s?

6 If a charge of 0.30 C moves from one point to another in a conductor and, in doing so, releases 54 J of electrical energy, what is the potential difference between the two points?

7 Describe the significance of two points in a conductor that are at the same electric potential. How much work must be done to move a charge between the two points?

8 How are electric potential energy and gravitational potential energy different? How are they similar?

Answers: 1) $9.7x10^4$J 2) 120V 3) 150s 4) 29C 5) 72J 6) 180V 7) no work

•

Resistance

- When charges pass through a material or device, they experience a ____________ to their flow
- This results in a _________ of electrical potential energy

Ohm's Law

- German scientist Georg Ohm (1787-1854) found that, for any conductor, the _________ of voltage to current is constant:

- The potential difference between any two points in a conductor varies _________ as the current between the two points (if the temperature remains constant).

$R = V/I$

R = resistance (ohms - Ω)
V = potential difference (volts - V);
I = current (amperes - A)

Ex.1: What is the resistance in a toaster, connected to a 120V power supply, if the current through it is 8.7 A?

Ex.2: Calculate the maximum rating (in volts) of a battery used to operate a toy electric motor that has a resistance of 2.4 Ω and runs at top speed with a current of 2.5 A.

Ex.3: How much current is supplied by a 6 V battery if it is connected to a light bulb with a resistance of 20 Ω?

Ohm's Law

1. Find the current through a 12-ohm resistive circuit when 24 volts is applied.

2. Find the resistance of a circuit that draws 0.06 A with 12 V applied.

3. Find the applied voltage of a circuit that draws 0.2 A through a 4800-ohm resistance.

4. Find the applied voltage in a telephone circuit that draws 0.017 A through a resistance of 15 000 ohms.

5. A 20 V relay has a resistance of 200 ohms. How much current does it draw?

6. A circuit consists of a 12 V battery connected across a single resistor. If the current in the circuit is 3 A, calculate the size of the resistor.

ANSWERS: 1) 2.0A 2) 200Ω 3) 960V 4) 255V 5) 0.1A 6) 4Ω

Power in Electric Circuits (Joule's Law)

- To predict the amount of energy used by an electrical device, we first need to know the amount of time the device will be used.

$$\Delta E = VI\Delta t$$

$$P = \Delta E/\Delta t$$

Therefore, $P = VI\Delta t/\Delta t$ or $P = VI$

Since $P = VI$ and $V = IR$

Then $P = (IR)\,I$

$P = I^2R$

Since $P=VI$ and $I = V/R$

Then $P = V\,(V/R)$

$P = V^2/R$

Ex.1: Calculate the resistance of a 7.5 W light bulb plugged into a 120 V household outlet.

Ex.2: What is the power rating on a light bulb with a resistance of 240 Ω if a 0.50A current runs through it?

Ex.3: A 110 V household circuit contains a 1800 W microwave and an 800 W coffee maker, which are connected to a 20 A fuse. Will the fuse melt if both the microwave and coffeemaker are on?

Power Equation

1. If a small appliance is rated at a current of 10 A and a voltage of 120 V, what is its power rating?

2. If a clock expends 2 W of power from a 1.5 V battery, what amount of current is supplying the clock?

3. Tommy runs his juicer every morning. The juicer uses 90 W of power and the current supplied is 4.5 A. How many volts are necessary to run the juicer?

4. A DC electric motor transforms 1.50 kW of electrical power into mechanical form. If the motor's operating voltage is 300 V, how much current does it "draw" when operating at full load (full power output)?

5. Calculate the amount of power dissipated by a heating element, if the generated output voltage is 110 V and the heater's resistance is 2.5 ohms?

6. What is the resistance in a lightbulb if it draws 1.5 W of power when it is connected to a 6 V battery?

7. A microwave has a power rating of 800 W. If it has a voltage of 120 V, what is the internal resistance of the microwave?

8. Calculate the resistance in a 3.6 W light bulb if a current of 0.6 A runs through it.

ANSWERS: 1) 1000W 2) 1.3A 3) 20V 4) 5A 5) 4800W 6) 20Ω 7) 20Ω 8) 10Ω

Chapter 9 Review

1. What is conventional current, and how does it relate to electron flow?

2. Differentiate between direct current and alternating current.

3. What would happen to the current in a circuit if the voltage of the battery doubles?

(doubles)

4. What would happen to the power in a circuit if both the current and the resistance double?

(increases by 8x)

6. What quantity of electric charge would flow through a small motor in 2.5 minutes if the circuit has a 5 A current?

750 C

7. How many electrons flowed through the motor in Question 13 in the 2.5 minutes?

$4.7x10^{21}$ electrons

8. Calculate the current if $1.0x10^{21}$ electrons flow through a circuit in 45 seconds.

3.6A

9. What is the potential difference across a battery if 0.12 J of energy is given off when $2.0x10^{-2}$C of charge flows through it.

6V

10. Calculate the energy provided by 12 V battery if 0.20 A of current flows through it for 3.0 minutes.

430 J

11. How many electrons flow through a 1.5 V battery in 1.0 minutes, if the current is 5.0 mA?

1.9×10^{18} electrons

12. How much work can be done by a 12 V battery if 2.0×10^{21} electrons can flow out of it before it is discharged?

3.8×10^{3} J

5. What current flows through a light bulb with 144Ω of resistance, if it is attached to a 120 V power source?

(0.83 A)

6. If a 10 A current flows through a 3Ω resistor, what is the voltage drop across the resistor?

(30V)

7. Your car's battery is a 12 V DC source. A fuse in the dashboard causes the circuit to break if there is a surge greater than 5.0 A. What resistance if that fuse protecting?

(2.4Ω)

8. A flashlight runs 2 D-Cells of 1.5 V each in series. The bulb is rated at 0.7 A. What is its resistance?

(4Ω)

9. A 900W electric stove is connected to a 220 V outlet. How much current will it draw?

(4A)

10. A 2.0W lightbulb has a resistance of 3.3Ω. What current is running through it?

(0.78A)

11. If a space heater produces 5400kJ of heat in 1.2 hours while plugged into a 110V outlet, how much current is flowing through the heater's element?

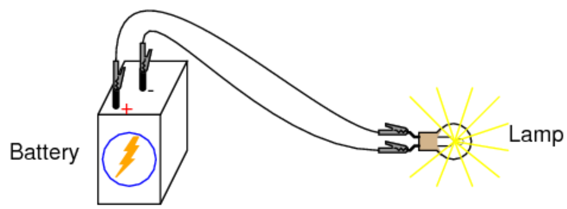
(11A)

Chapter 10: Electric Circuits

- Electrons possess electric potential energy that can be transformed into __________, light, and __________.

- For such transformations to occur, a source of electric potential energy needs to connect to one or more components by means of an electric __________ (path for electric current)

- Any device in a circuit that converts electric potential energy into some other form of energy (causing an electric potential drop) is called a __________.



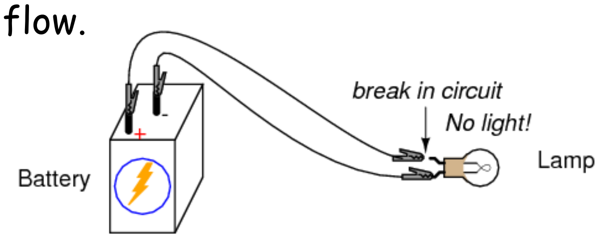
- In the above circuit, the charges pass from the __________ terminal of the battery, through the _____________, and then back to the negative terminal of the battery.

- Electric potential energy acquired in the __________ is carried by electric __________ as they pass through the circuit.

- The electric potential energy is _____________ to the light bulb and converted to light and heat.

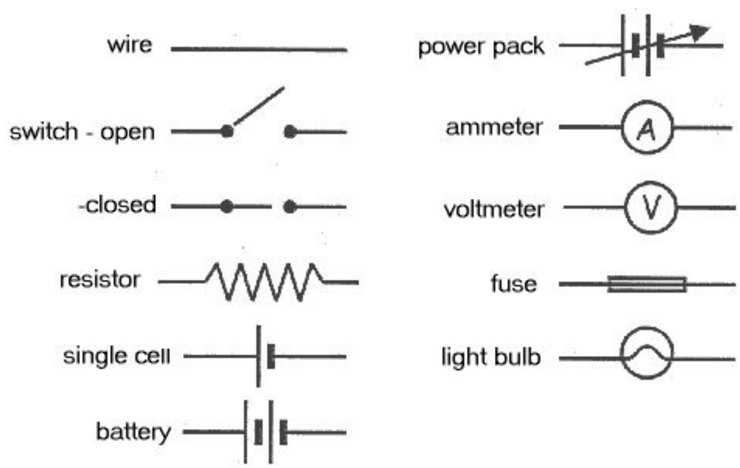
- Electric current can only flow through a circuit if there is a __________ conducting path.

- Any ________ in the circuit will stop the flow.

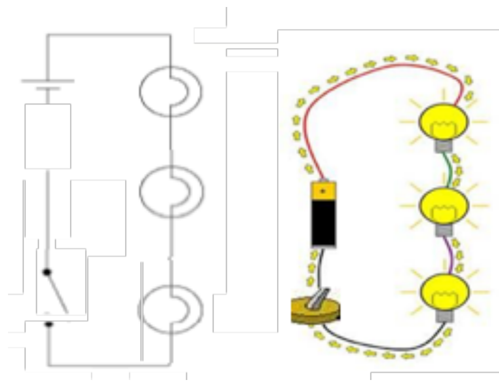


Circuits

Any circuit can be represented with a ______________ diagram using a set of common symbols:



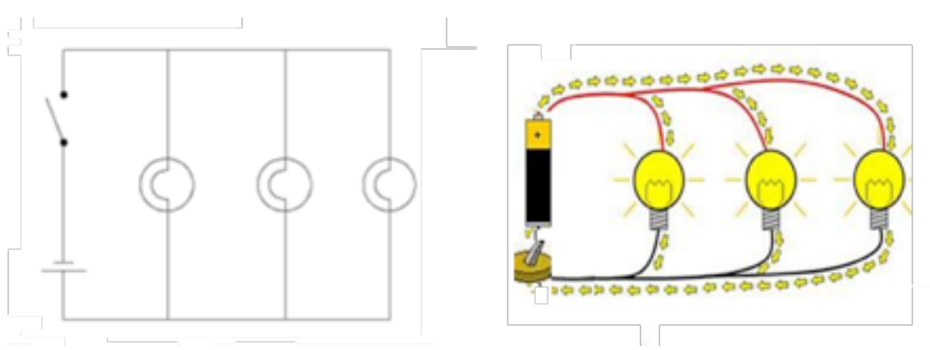
Series Circuits



- Simple way of joining several __________ together
- Charges have only ______ conducting path

Parallel Circuits

- Charges can move along __________ paths through the circuit
- Charge could pass through only one of the several __________ before returning to the energy source.



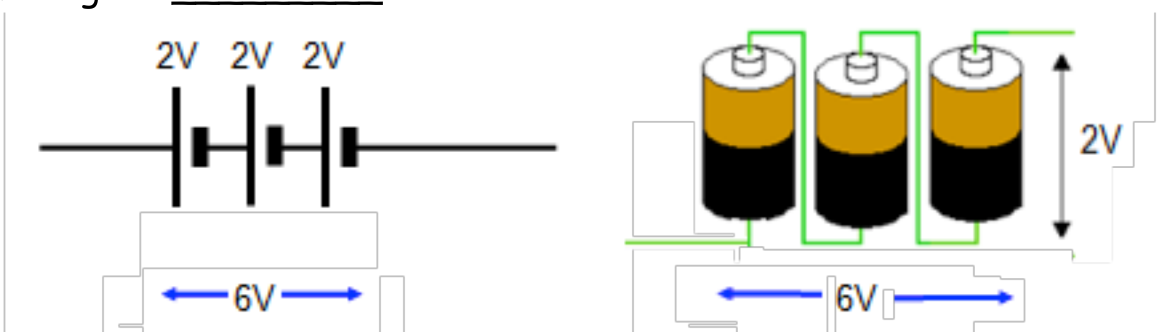
Cells vs. Batteries

Chemical Cell – electrochemical device that converts _________ energy into electrical energy

Battery – collection of _________ that work together to provide electrical energy to a circuit

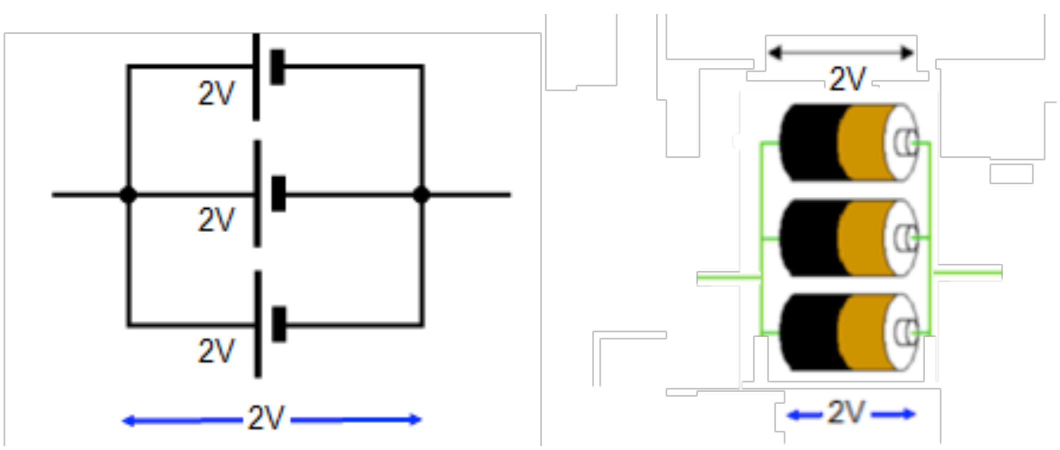
Cells in Series

- _________ terminal is connected to ________ terminal of another cell
- Voltage is _________



Cells in Parallel

- Positive terminals are connected _________
- Voltage is _________, but increases the _________ that flows



Circuit diagram worksheet

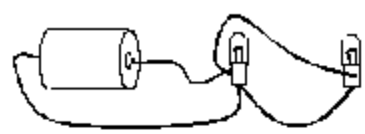
PART 1 - Convert the following descriptions to schematic circuit diagrams. Remember to always use a ruler when drawing circuit diagrams.

1. Draw a circuit diagram containing a battery with 2 dry cells in series, one pathway with an open switch and a lamp. Show the direction of electron flow.	2. Draw a circuit diagram containing a battery with 2 dry cells in parallel, one pathway with a closed switch and a lamp. Show the direction of electron flow.
3. Draw a circuit diagram containing a battery with 3 cells in series, two pathways with a lamp on each path. Add a switch that would control the lamps on both paths. Show the direction of electron flow.	4. Draw a circuit diagram containing a battery with 4 cells in series, three pathways and a lamp on each path. Add switches to control each of the lamps and a fourth switch to control all of the lamps. Show the direction of electron flow.

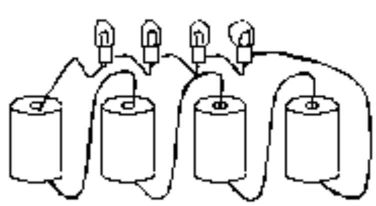
PART 2 - Convert the following pictorials to schematic circuit diagrams. Write descriptions for each pictorial.

1.

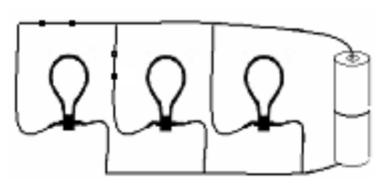
3.



2.



4.



Kirchhoff's Laws for Electric Currents

Law of Conservation of Energy

- As electrons move through an electric circuit, they _________ energy in sources and _________ energy in loads
- The total energy gained in one trip through a circuit is _________ to the total energy lost.

Law of Conservation of Charge

- Electric charge is neither _________ nor _________ in an electric circuit, nor does it _________ at any point in the circuit.

Kirchhoff's Voltage Law:

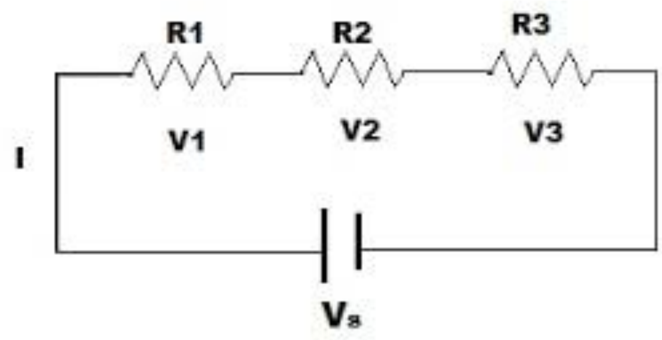
- Around any complete path through an electric circuit, the _________ of the increases in electric potential is _________ to the sum of the decreases in electric potential

Kirchhoff's Current Law:

- At any junction point in an electric circuit, the _________ electric current into the junction is _________ to the total electric current out.

Resistance in Series

$V_s = V_1 + V_2 + V_3$



$I_sR_s = I_1R_1 + I_2R_2 + I_3R_3$

Since $I_s = I_1 = I_2 = I_3$

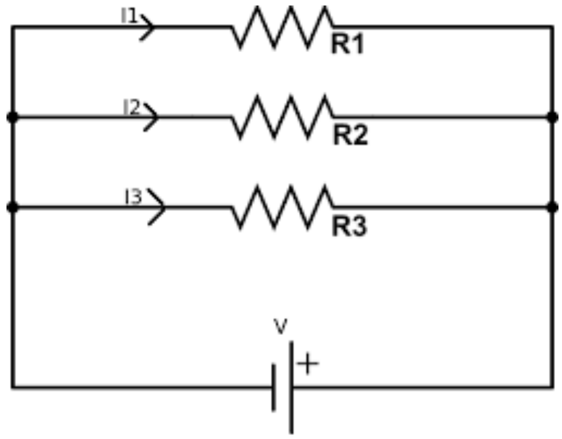
Then $R_s = R_1 + R_2 + R_3$

_____________ Resistor: Resistor that has the same current and potential difference as the resistors it replaces.

Ex.1: What is the equivalent resistor in a series circuit containing a 16 Ω light bulb, a 27 Ω heater, and a 12 Ω motor?

Ex.2: A 22 Ω, and 18 Ω and an unknown resistor are connected in series to give an equivalent resistance of 64 Ω. What is the resistance of the unknown resistor?

Resistance in Parallel



$I_P = I_1 + I_2 + I_3$

$I_1 = V_1/R_1 \quad I_2 = V_2/R_2 \quad I_3 = V_3/R_3$

$V_P/R_P = V_1/R_1 + V_2/R_2 + V_3/R_3$

Since $V_P = V_1 = V_2 = V_3$

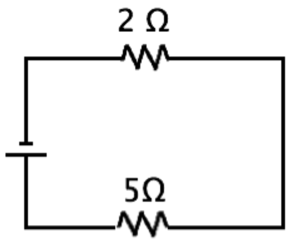
$1/R_P = 1/R_1 + 1/R_2 + 1/R_3$

Example #1: Find the equivalent resistor when a 4.0 Ω bulb and a 8.0 Ω bulb are connected in parallel.

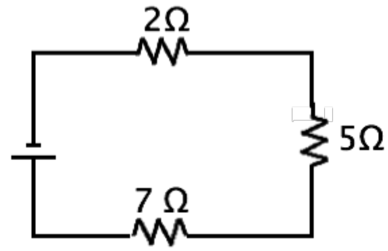
Example #2: Calculate the equivalent resistance of two, three, four and five 60 Ω bulbs in parallel. What is the simple relationship for the equivalent resistance of n equal resistances in parallel?

Determine the equivalent (total) resistance for each of the following circuits below.

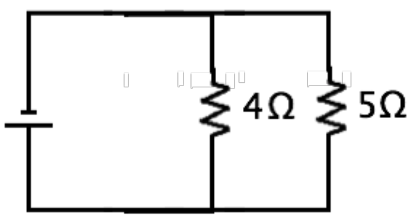
4.



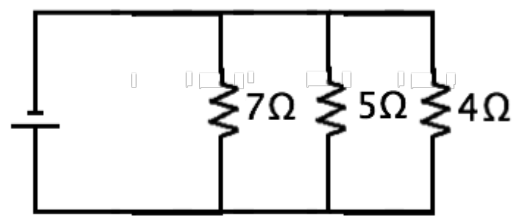
2.



3.

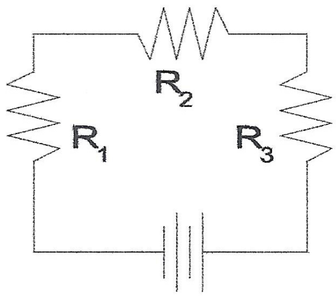


4.



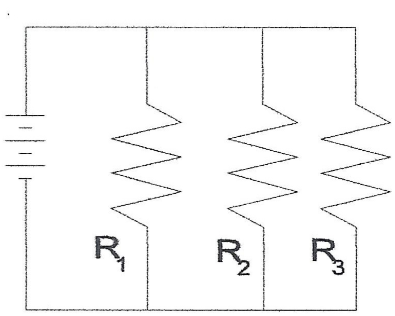
Resolving Electric Circuits

1. Fill out the table for the circuit below.



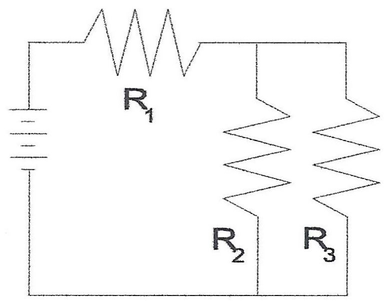
Circuit Position	Voltage (V)	Current (A)	Resistance (Ω)
1			10.0
2			20.0
3			30.0
Total	6.00		

2. Fill out the table for the circuit below.



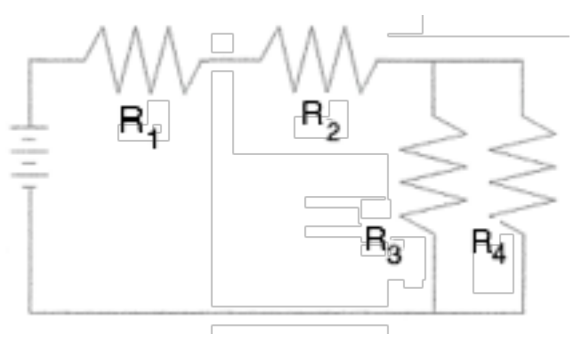
Circuit Position	Voltage (V)	Current (A)	Resistance (Ω)
1			10.0
2			20.0
3			30.0
Total	6.00		

3. Fill out the table for the circuit below.



Circuit Position	Voltage (V)	Current (A)	Resistance (Ω)
1			10.0
2			20.0
3			30.0
Total	6.00		

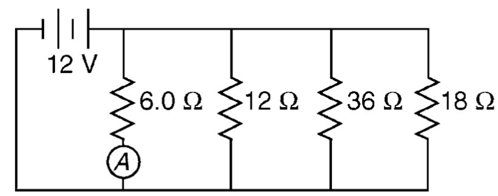
4. Fill out the table for the circuit below.



Circuit Position	Voltage (V)	Current (A)	Resistance (Ω)
1			8.00
2			20.0
3			20.0
4			30.0
Total	120		

CIRCUITS WORKSHEET

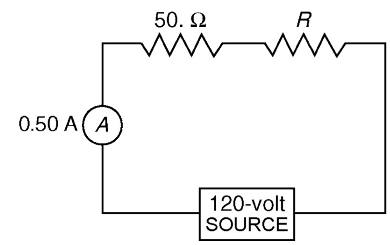
1. a) What is the equivalent resistance in the adjacent circuit?



b) What is the current measured by ammeter *A*?

(3.0 Ω, 2.0 A)

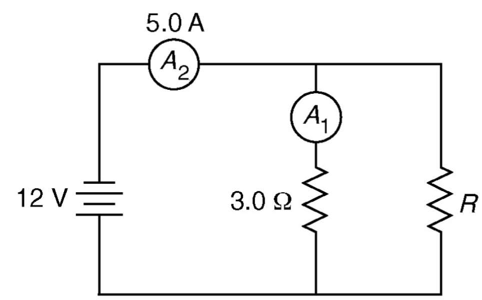
2. A 50.-ohm resistor, an unknown resistor *R*, a 120-volt source, and an ammeter are connected in a complete circuit. The ammeter reads 0.50 ampere.
   a) Calculate the equivalent resistance of the circuit shown.



   b) Determine the resistance of resistor *R* shown in the diagram.

(240 Ω, 190 Ω)

3. A 3.0-ohm resistor, an unknown resistor, *R*, and two ammeters, A_1 and A_2, are connected as shown below with a 12-volt source. Ammeter A_2 reads a current of 5.0 amperes.
   a) Determine the equivalent resistance of the circuit shown.



   b) Calculate the current measured by ammeter A_1 in the diagram shown.

   c) Calculate the resistance of the unknown resistor, *R* in the diagram shown.

(2.4 Ω, 4.0 A, 12 Ω)

4. The load across a 50.0-V battery consists of a series combination of two lamps with resistances of 125 Ω and 225 Ω.
   a) Find the total resistance of the circuit.

   b) Find the current in the circuit.

   c) Find the potential difference across the 125-Ω lamp.

(350 Ω, 0.143 Ω, 17.9 V)

5. The load across a 40-V battery consists of a series combination of three resistances R_1, R_2, and R_3. R_1 is 240 Ω and R_3 is 120 Ω. The potential difference across R_1 is 24 V.
   a) Find the current in the circuit.

   b) Find the equivalent resistance of the circuit.

   c) Find the resistance of R_2.

(0.1A, 400Ω, 40Ω)

6. The load across a 12-V battery consists of a series combination of three resistances R_1, R_2, and R_3. R_1 is 210 Ω, R_2 is 350 Ω, and R_3 is 120 Ω.
   a) Find the equivalent resistance of the circuit.

   b) Find the current in the circuit.

   c) Find the potential difference across R_3.

(680Ω, 0.018A, 2.2V)

7. Three resistances of 12 Ω each are connected in parallel. What is the equivalent resistance?

(4.0Ω)

8. Two resistances, one 62 Ω and the other 88 Ω, are connected in parallel. The resistors are then connected to a 12-V battery.
   a) What is the equivalent resistance of the parallel combination?

   b) What is the current through each resistor?

(36Ω, 0.19A, 0.14A)

9. A 15.0-Ω resistor is connected in series to a 120-V generator and two 10.0-Ω resistors that are connected in parallel to each other.
   a) Draw the circuit diagram.

   b) What is the total resistance of the load?

   c) What is the magnitude of the circuit current?

   d) What is the potential difference across the 15.0-Ω resistor?

   e) What is the current in one of the 10.0-Ω resistors?

(20.0Ω, 6.0A, 90.V, 3.0A)

Electrical Power and Energy Costs

- ELECTRICAL _________ is the rate at which electrical energy is _________ OR _________. For example, a 60W incandescent light bulb used ____ of electrical energy every _________.
- A KILOWATT-HOUR (______) is the scientific international (SI) unit used to measure energy usage.
- One kilowatt-hour is the amount of _________ a 1000W device would consume in one hour.

$$1\text{ kW-h} = 1000\text{J/s} \times 3600\text{s} = 3.6\times10^{6}\text{ J}$$

- You can tell how much _________ a device will use by reading the power rating label.
- Electricity _________ keep track of how much electrical energy is used in a home.

Cost to Operate = Power Rating x Time x Cost of Electricity

Ex 1: A motor uses 150 W. Electricity costs 5.6¢ /kW-h. How much would it cost to operate the motor for 1 day (24 hours)? For 1 year?

Ex 2: A 0.50 A light bulb is connected to a 120V outlet at your house. If the BC Hydro rate is 8.58¢/kW-h, how much will it cost to run the lightbulb 4 hours per day for 30 days?

Electrical Power & Energy

1. Make the following conversions:
   a. 1.5W = _____ kW
   b. 45.2W = _____ kW
   c. 23 min = _______ h
   d. 365 days = _______ h

2. Your oven has a power rating of 5,000 watts.
   a. How many kilowatts is this? ________
   b. If the oven is used for 2.4 hours to bake cookies, how many kilowatt-hours (kWh) are used?

   c. If your town charges $0.15 per kWh, what is the cost to use the oven to bake the cookies?

3. For each of the appliances listed below, calculate the wattage in kilowatts and the cost per hour of use. Assume your town charges $0.10 per kWh.

Appliance	Watts	Kilowatts	Cost per Hour
Samsung Microwave	1200 W		
Kitchen Aid Mixer	325 W		
Kitchen Aid Coffee Maker	1360 W		
Philips TV	105 W		
Sharp DVD Player	14 W		
Samsung VCR	17 W		
Denon Receiver	100 W		
Denon CD Player			

4. Does it cost more to bake a potato in a microwave or in a conventional oven? Show your work. Assume it takes 1 hour to bake in the oven and 15 minute to bake in the microwave.

5. A light bulb is on for 2.5 hours. If the amount of electrical energy used is 30.0 kW*h, what is the power rating of the light bulb?

6. A 300W waffle iron is used for 30 minutes. Calculate the energy consumed in both joules and kW*h.

7. The current in a washing machine is 20 A when it is plugged into a 120V outlet.
   a. What is the power rating of the clothes dryer?

   b. If BC Hydro charges 8.5¢/kW*h, how much would it cost to run the clothes dryer over a year, if it runs on average four hours a week?

8. How much would it cost to leave your computer on for 4 days if it drew 75W of power and the cost of electricity is $0.20 per kW*h?

ANSWERS: 1a) 0.0015kW b) 0.042kW c) 0.38h d) 8760h 2a) 5kW b) 12kW*h c) $1.80 4) 4.5kW*h vs. 0.3kW*h 5) 12W 6) 5.4×10^5J or 0.15kW*h 7) $42.43 8) $1.44

Efficiency

Law of Conservation of Energy: the amount of energy present _________ an energy transformation is equal to the amount of energy present _________ the energy transformation.

However, some of the energy in a transformation is not a _________ form of energy and is _________.

$$\text{Efficiency} = \frac{\text{Energy output}}{\text{Energy input}} \times 100$$

- _________ - the ability of a device to convert energy
- Energy _________– useful energy produced by a converter (J)
- Energy _________ – energy consumed by the converter (J)

Converter	Input energy	Output energy
Car engine	_________ (gasoline)	_________ (motion)

Ex#1: An internal combustion engine burns 1200J of chemical energy. The fuel is vaporized, producing very high pressures that push down on the pistons which turn the crankshaft, thus turning the wheels. In the end, only 100 J of mechanical energy is produced to move the car forward. What is the efficiency of the car's engine?

Ex#2: A 1200 W electric kettle is used for 10 minutes.

a) How much energy does it require?

b) If 6.0×10^5 J of energy is transferred to the water in the kettle, what is its efficiency?

Efficiency

1. How much electrical energy does a 1200 W electric kettle use in each of the following times?
    a. 1.0 s__________
    b. 1.0 min __________
    c. 1.0 h __________
    d. 1.0 day __________

2. How much heat energy does it take to heat 2.0 kg of water from 10°C to 100°C?

3. How long would it take a 1000 W kettle to do the job described in question 2, assuming that it is 100% efficient?

4. Several friends use a simple rope and pulley to raise a tree house from the ground into a tree. The mass of the tree house is 150 kg. By pulling together, the friends manage exert an average force of 1.6×10^3 N as they raise the tree house a distance of 3.2 m above the ground.

    a) How much work did the friends actually do to raise the tree house?

    b) How much "useful" work was done?

    c) What is the efficiency of the rope and pulley in raising the treehouse?

    d) Suggest why the efficiency of this simple machine is not 100%.

5. A container factory uses a 370 W motor to operate a conveyor belt that lifts containers from one floor to another. To raise 250 1-kg containers a vertical distance of 3.6 m, the motor runs for 45 s.

   a) Determine the useful energy output.

   b) How much energy does the motor use?

   c) What is the efficiency of the motorized conveyor system?

6. A 60.0 kg mountain climber decides to climb a mountain that is 4.0×10^3 m high.

   a) How much potential energy is gained by the climber by climbing to the top of the mountain?

   b) If the body's efficiency in converting energy stored as fat to mechanical energy is 25%, determine the amount of amount of energy stored that the climber will use up in providing the energy required to raise the climber up the mountain.

   c) It is estimated that one kilogram of body fat will provide 3.8×10^7 J of energy. What amount of fat will the climber burn while climbing the mountain?

ANSWERS: 1a) 1200J b) 7.2×10^4J c) 4.3×10^6J d) 1.0×10^8J 2) 7.5×10^5J 3) 750s 4a) 5100J b) 4700J c) 92% d) friction 5a) 8.8×10^3J b) 1.7×10^4J c) 53% 6a) 2.4×10^6J b) 9.4×10^6J c) 0.25kg

Chapter 10 Review

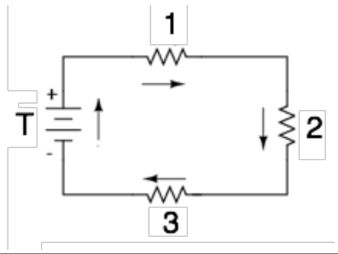
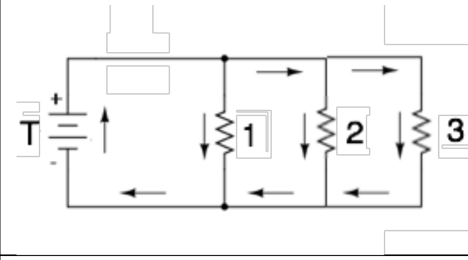
1. What is the difference between a series circuit and a parallel circuit? Include a sketch in your answer.

12. What is the difference between a cell and a battery?

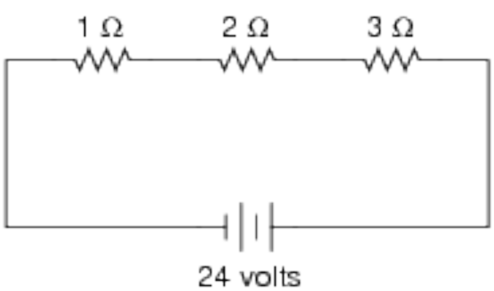
2. Draw a schematic diagram of:

a) a circuit containing a three-cell battery, two light bulbs, a resistor, and a switch, all connected in series.	
b) A circuit containing two lightbulbs connected in parallel, with a two-cell battery as its power source. Include switches that would turn both lights off at the same time.	
c) A circuit containing three light bulbs, one which is more bright than the other two. Include a switch that will turn off only the two dimmer bulbs, and two cells connected in parallel	

3. Summarize the following relationships for a series and parallel circuit:

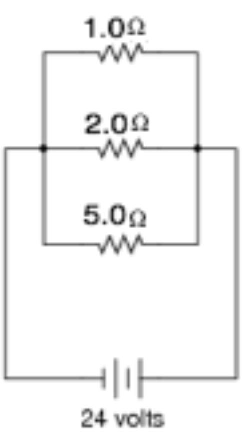
Type of Circuit	Series Circuit	Parallel Circuit
Schematic		
Potential Difference		
Current		
Resistance		

4. In this circuit, three resistors receive the same amount of current from a single source. a) the current in the circuit. Calculate:
   b) the amount of voltage “dropped” by each resistor
   c) the amount of power dissipated by each resistor:



(a) 4A; b) 4V, 8V, 16V; c) 16W; 32W; 48W)

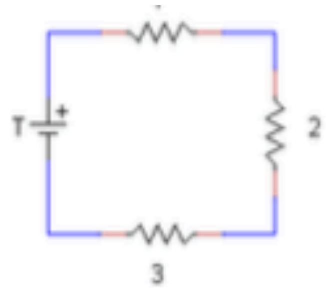
5. In this circuit, three resistors receive the same amount of voltage (24 volts) from a single source. Calculate:
   a) The equivalent resistor for the three resistors;
   b) The total current coming out of the battery;
   c) the amount of current “drawn” by each resistor;



(a) 0.59Ω; b) 41A; c) 24A, 12A, 4.8A)

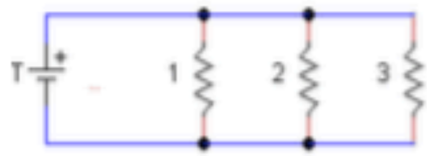
6. Resolve the following Circuits:

a)



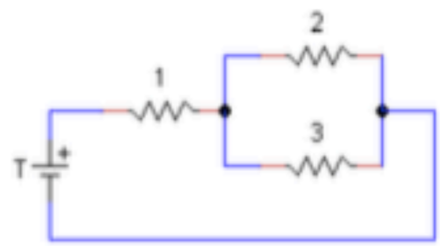
	V	I	R	P
1			5	
2		2		
3			10	
T	120			

b)



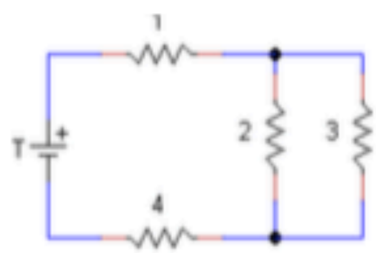
	V	I	R	P
1	30			90
2		2		
3			10	
T				

c)



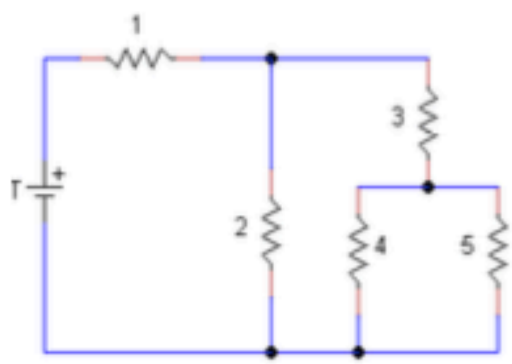
	V	I	R	P
1			10	
2		2		
3				40
T		6		

d)



	V	I	R	P
1		4	10	
2		1		
3	30			
4				
T	90			

e)
*Challenge



	V	I	R	P
1			20	
2	80			400
3		3		
4		1		
5	60			
T	240		30	

a)

	V	I	R	P
1	10	2	5	20
2	90	2	45	180
3	20	2	10	40
T	120	2	60	240

b)

	V	I	R	P
1	30	3	10	90
2	30	2	15	60
3	30	3	10	90
T	30	8	3.75	240

c)

	V	I	R	P
1	60	6	10	360
2	10	2	5	20
3	10	4	2.5	40
T	70	6	11.7	420

d)

	V	I	R	P
1	40	4	10	160
2	30	1	30	30
3	30	3	10	90
4	20	4	5	80
T	90	4	22.5	360

e)

	V	I	R	P
1	160	8	20	1280
2	80	5	16	400
3	20	3	6.7	60
4	60	1	60	60
5	60	2	30	120
T	240	8	30	1920

Chapter 11: Waves

Wave Properties

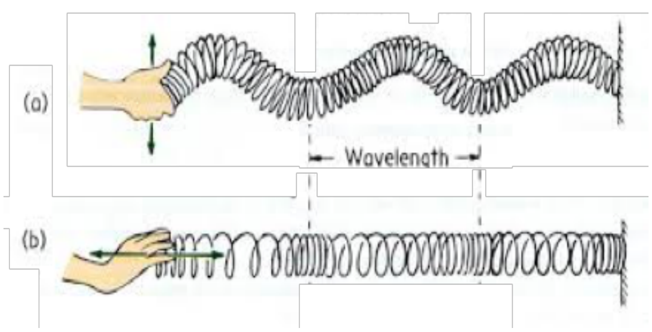
- mechanical waves require a ____________ (water, air, springs)
- _______________ waves require no medium (light, radio, micro)

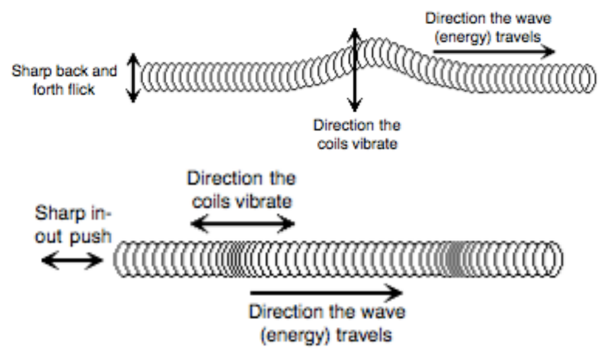
Types of Mechanical Waves

Two Wave Types

Transverse Wave – Particles of the medium vibrate ______________ to the direction of the wave.

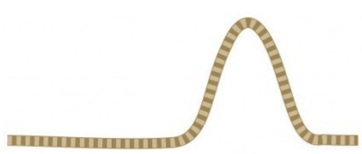
Longitudinal (Compression) Wave – Particles of the medium vibrate in the ______________ direction as the wave.





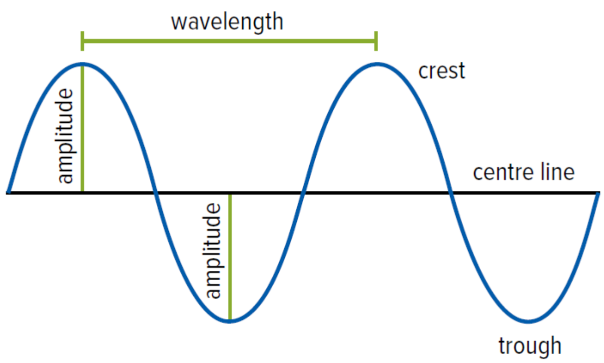
Pulse Wave: a __________ disturbance that travels through a medium.

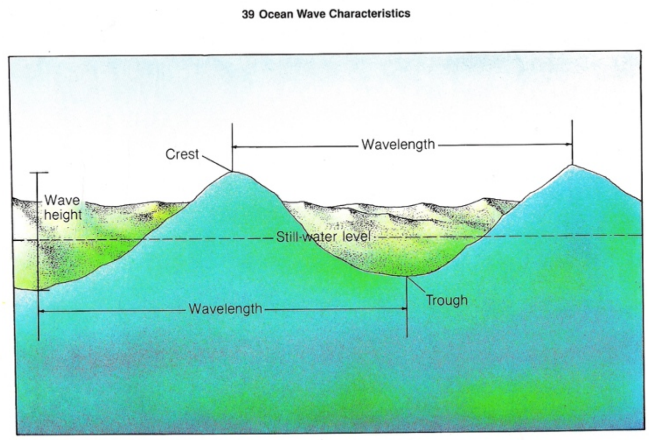
Periodic Wave: a _________ of pulses formed from regularly repeated vibrations.



Pulse Wave : source is a non-periodic disturbance

Periodic Wave : source is a periodic oscillation





Parts of a Wave

- A water wave has two main parts – a high point called the _________, and a low point called the _________.
- The distance between one crest and the next (or between one trough and the next) is called the _________________.
- The distance between a crest or a trough of a wave to the rest position (centre line) is called the _______________.

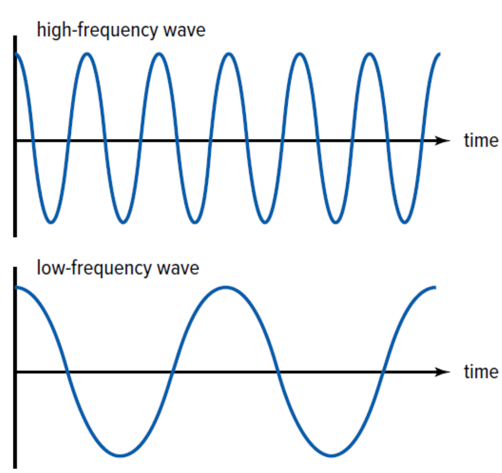
Properties of a Periodic Wave

Period (T) - the time needed for ______ complete cycle or wave.

Frequency (Hz) - the ___________ of complete cycles per ___________.

$$f = \frac{1}{T}$$

$$T = \frac{1}{f}$$



Ex#1: A swing rocks back and forth 15 times in one minute.

a)What is the frequency of the swing?

b)What is the period of vibration of the swing?

Ex#2: A pendulum takes 5 s to complete one swing.

a) What is the frequency of the pendulum?

b) How many times will the pendulum swing in one hour?

Wave Velocity

- the product of the ___________ and the _________________.

We know: $v = \frac{d}{t}$ or $v = \frac{\lambda}{T}$

But if $T = 1/f$

Then by substitution: $v = f\lambda$

v = _______________ of the wave (m/s)

f = _______________ (Hz)

λ = _______________ (m)

Ex#1: The wavelength of a water wave is 0.55 m. If the frequency of the wave is 4.0 Hz, what is the speed of the wave?

Ex#2: A hiker on Mount Baker shouts across a valley to the other hillside, 750 m away. The echo is heard 4.4 s later.

a) What is the speed of sound in air.

b) If the sound's frequency is 436 Hz, what is the wavelength?

Ex#3. Mac and Josh stand 8 m apart and demonstrate the motion of a transverse wave on a snakey. The wave has a vertical distance of 32 cm from a trough to a crest, a frequency of 2.4 Hz, and a horizontal distance of 48 cm from a crest to the nearest trough. Determine the amplitude, wavelength and speed of such a wave.

Wave Equation

1. Radio Station WBOS in Boston broadcasts at a frequency of 29.9 MHz. What is the wavelength of the radio waves emitted by WBOS?
   MHz= Megahertz= 1 million Hertz or 1.00×10^6 Hz; The velocity of a electromagnetic waves is 3.00×10^8 m/s.

2. In California, Clay is surfing on a wave that propels him toward the beach with a speed of 5.0 m/s. The wave crests are each 20m apart. A) What is the frequency of the water wave? B) What is the Period?

3. Harriet is told by her doctor that her heart rate is 70.0 beats per minute. If Harriet's average of blood flow in the aorta during the systole is 1.5×10^{-2} m/s, what is the wavelength of the waves of blood in Harriet's aorta, created by her beating heart?

4. Dogs are able to hear much higher frequencies than humans are capable of detecting. For this reason, dog whistles that are inaudible to the human ear can be heard easily by a dog. If a dog whistle has a frequency of 3.0×10^4 Hz, what is the wavelength of the sound emitted? *Speed of sound waves in air is 340m/s*

5. While flying to Tucson, Connie's' plane experiences turbulence that causes the coffee in her cup to oscillate back and forth 4 times each second. If the waves of coffee have a wavelength of 0.1m, what is the speed of a wave moving through the coffee?

6. At a country music festival in New Hampshire, the Oak Ridge Boys are playing at the end of a crowded 184-m field when Ronny Fairchild hits a note on the keyboard that has a frequency of 440 Hz. A) How many full wavelengths are there between the stage and the last row of the crowd? B) How much delay is there between the time a note is played and the time it is heard in the last row? *Speed of sound waves in air about 340.0 m/s*

7. Radio Station KSON in San Diego broadcasts at both 1240 kHz (AM) and 97.3 MHz (FM). A) Which of these signals, AM or FM, has the longer wavelength? B) How long is each? *Remember, radio waves are what kind of waves?*

8. What is the wavelength of a B note (frequency 494 Hz) played by a flute?

9. Find the wavelength of the ultrasonic wave emitted by a bat if it has a frequency of 4.0×10^4 Hz. *(This is a sound wave.)*

10. A popular pastime at sporting events is "the wave", a phenomenon where individuals in the crowd stand up and sit down in sequence, causing a giant ripple of people. If a continuous "wave" passes through a stadium of people with a speed of 20 m/s and a frequency of 0.5Hz, what is the distance from "crest" to "crest" (in other words, the wavelength of the wave)?

Wave Velocity

- Wave __________ is dependent upon the medium.

  eg. spring tension, water depth
- If speed decreases, wavelength ________ (frequency remains constant).
- Frequency can only be changed at the __________.
- If frequency increases, wavelength will ________ to maintain the same speed..

Amplitude of a Wave

- the amplitude of a wave is its ____________ displacement from the rest position.
- in order to produce a wave with ________ amplitude, more work has to be done.

<u>Wave Phenomena</u>

Wave Interference

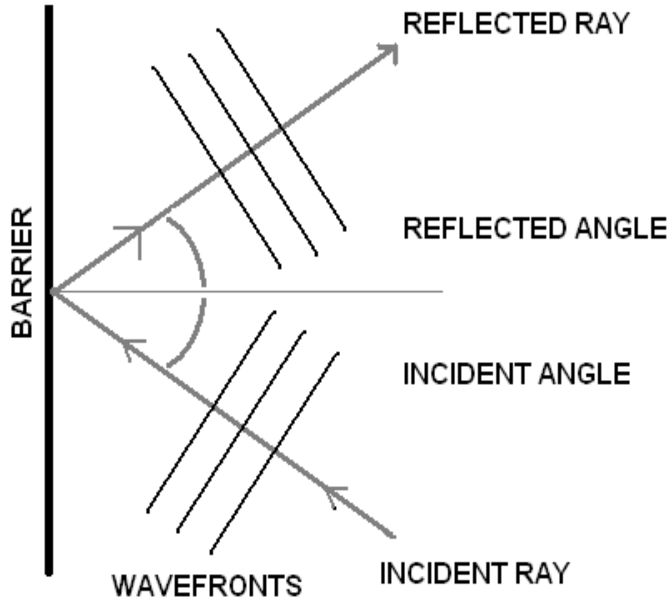
The speed of a mechanical wave depends upon the __________

e.g. depth of water, temperature or the air, spring tension

When a wave hits a boundary or moves from one medium to another, it will be __________, __________, and/or __________.

- Reflected wave: bounces ________ in the direction it came from
- Refracted wave: continues forward but changes ________ and ________ as it enters the new medium
- Absorbed wave: wave energy is converted to other forms such as ________ and ________

Reflection of Waves

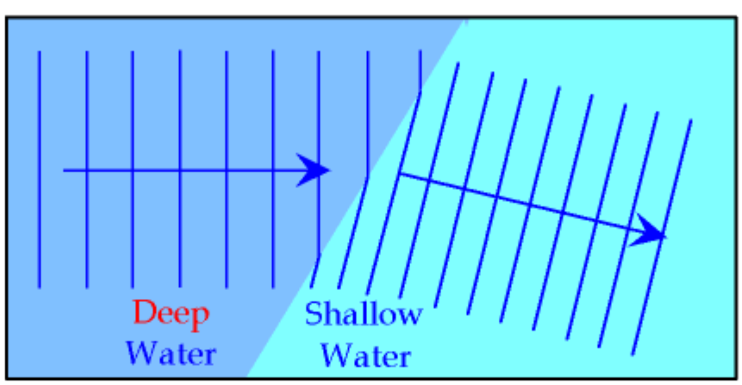


Law of Reflection - angle of _______________ is equal to the angle of ___________________.

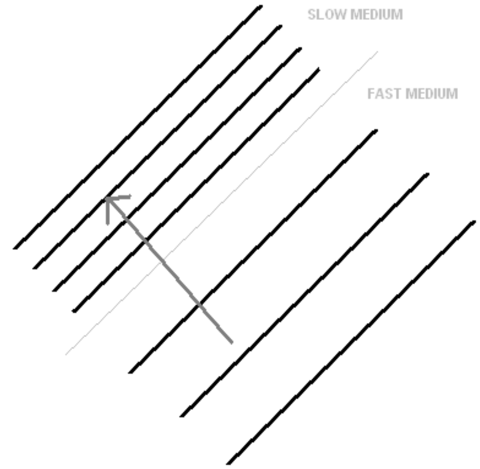
- reflected wave decreases in _____________ (waves lose energy due to friction and absorption by barrier).

Refraction

- waves change ____________, ____________, and _____________ at the boundary between 2 different media (ie. different depths of water)

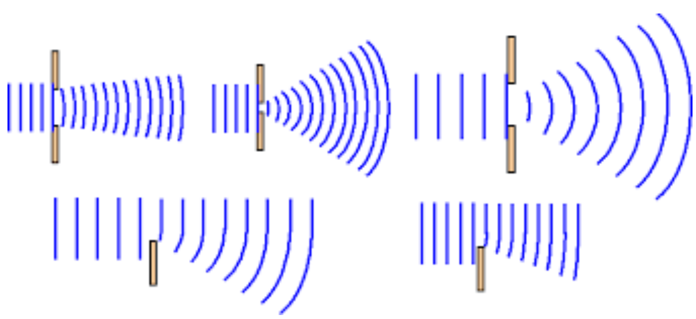


- when waves enter shallow water:
  a) frequency is the __________(only changed at the source)
  b) wavelength __________
  c) speed ___________



Diffraction

- the ________________ of waves around the edge of a barrier.
- waves will _______ as they pass through an opening or around an obstacle.
- greater wavelength = ___________ diffraction.



Superposition of Waves

- the __________ displacement of a particle caused by two or more waves.
- equal to the _____ of the displacements produced by individual waves.

Constructive Interference

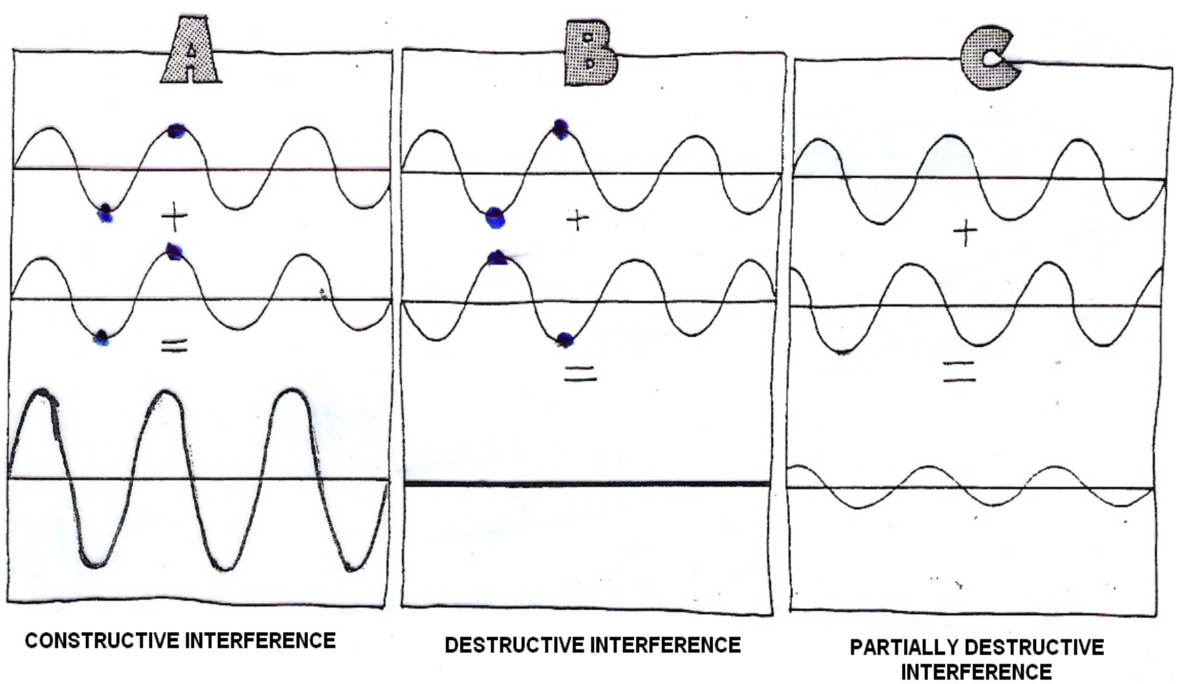
- troughs of the 2 waves occur at the same time; combined wave is ___________ than each of the separate waves.

Destructive Interference

- crests of one wave arrives at the same time as the troughs of the other wave; net _______________ is zero.

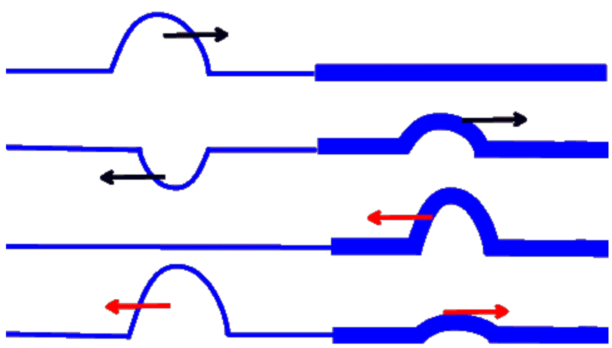
Partially Destructive Interference

- when 2 waves meet somewhere _________ the 2 extremes, or if waves have different ______________ or different ________________.



Boundary Behaviour

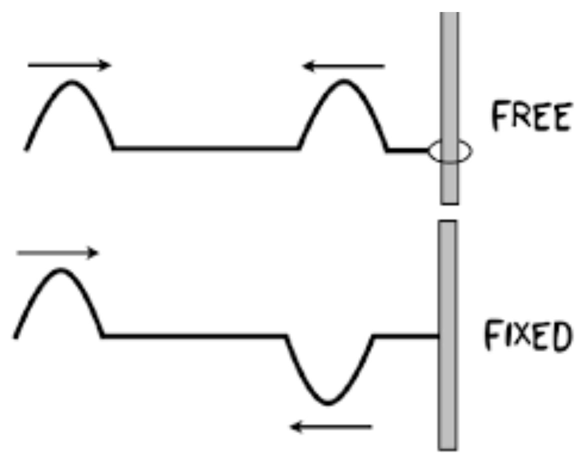
When a wave travels between media with different densities, it is both reflected and transmitted (refracted).



Less Dense to More Dense: Reflected wave is __________

More dense to less dense: Reflected wave is __________

*** TRANSMITTED WAVE IS ALWAYS ERECT**



Free End
(______ dense to _____ dense):
Reflected wave is erect.

Fixed End
(______ dense to ______ dense):
Reflected wave is inverted.

Standing Waves

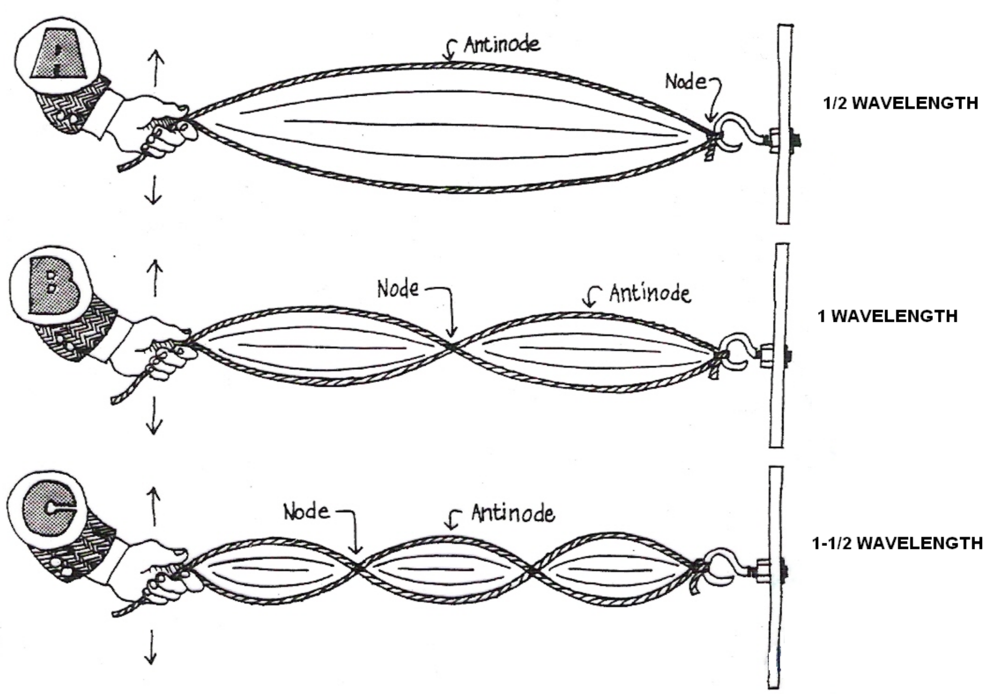
- when waves of identical __________ and __________ interfere, a stationary interference pattern is produced.
- __________ and __________ waves interfere in such a way that constructive and destructive interference occurs at ________ positions.

Nodes

- parts of the wave that remain ______________.
- points of complete _____________ interference.

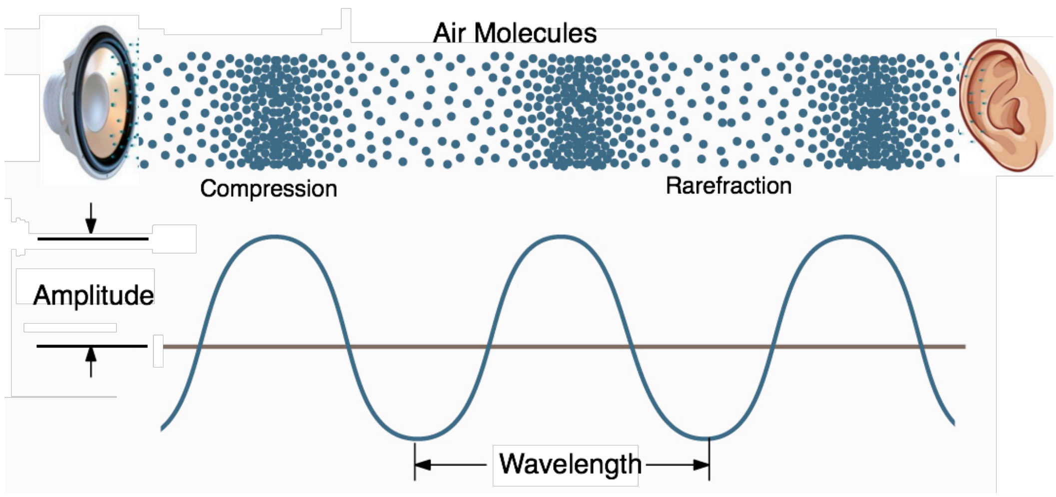
Antinodes

- positions with the ___________ amplitude.
- points of maximum _____________ interference.



Chapter 12: Sound

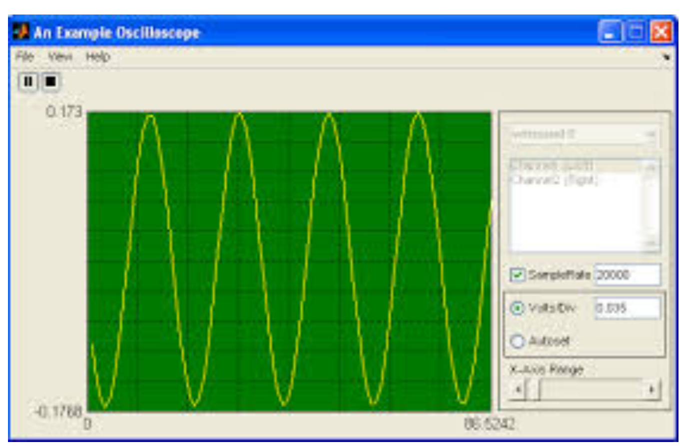
- To create sound, an object needs to produce _______________.
- Air molecules around the vibrating source collide with other air molecules, forming region of _______________ air.
- In between compressions, the air molecules spread out (_____________).
- These compression waves spread out in all directions from the source.
- When the compression wave reaches your ear, your ear drum vibrates with the same _______________ produced by the sound source.



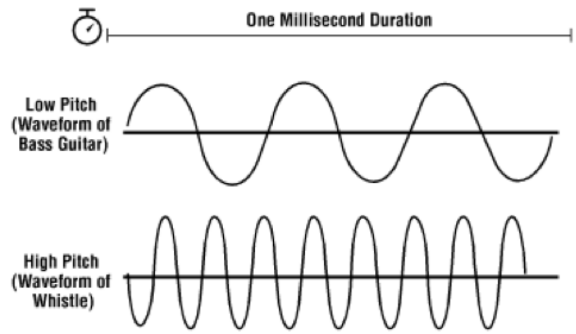
Oscilloscope – device that allows us to see sound waves as _________ waves.

Compression (high air pressure) produces a _______________

Rarefraction (low air pressure) produces a _______________



Pitch



- ______________ of a sound
  - Low Pitch – ______ wavelength
  - High Pitch – ______ wavelength

- Audible Frequency Range: 20 Hz to 20 000 Hz (1 Hz = 1 vibration/second)

  Infrasonic: <20 Hz (very low frequency)

  Ultrasonic: >20,000 Hz (very high frequency)

Loudness

- ______________ of the sound wave
- Stronger compressions produce _________ waves on the oscilloscope.
- Sound Intensity = amount of sound ______________ arriving every second on a one square metre area.

$$\text{Sound Intensity} = \frac{\text{Energy}}{\text{second} \bullet \text{square metre}} = \frac{\text{Power}}{m^2} = \frac{\text{Watt}}{m^2}$$

Sound Threshold for Human Hearing = 10^{-12} W/m^2

- Loudness of Sound is often compared to the sound threshold as a ratio, which is converted to a unit called the ______________.

$$\text{Ratio} = \frac{\text{Sound Intensity}}{\text{Sound Threshold}} = 10^n\ ;\ n = \#\ \text{bels}$$

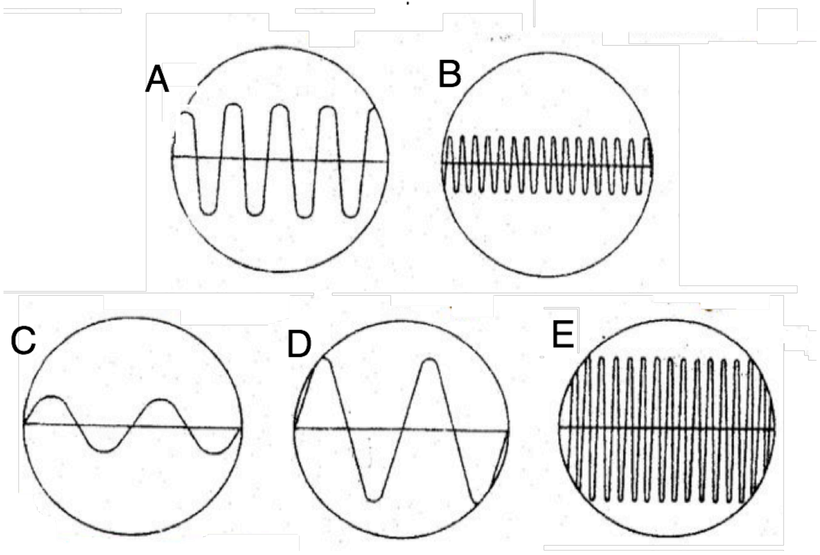
Ex#1: A quiet conversation has a sound intensity of 10^{-6} W/m^2. Express the loudness of the sound in decibels.

Ex#2: A sound meter measures the noise produced at a pep rally as 100 dB. Determine the sound intensity.

Pitch and Loudness

Determine which of the following diagrams is:

1. Loud and low-pitched
2. Soft and high-pitched
3. Loud and high-pitched
4. Soft and low-pitched
5. Medium-loud and medium-pitched.

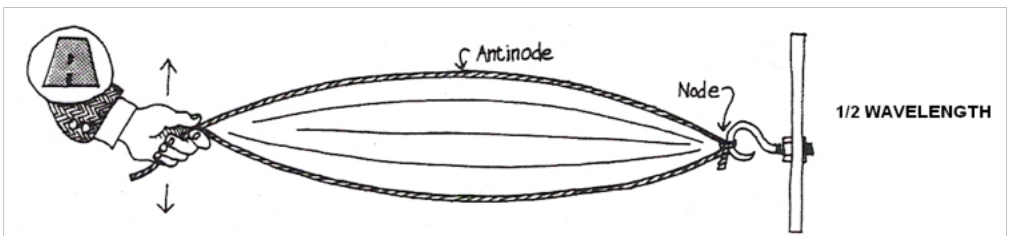


	COMMON SOUNDS	DECIBEL LEVELS dB(A)
DAMAGING	rock concert, jet takeoff, gun shot	120 to 140
	chainsaw, air gun, portable stereo, dance club, boiler room, sandblasting	100 to 120
HARMFUL	power tools, motorcycle, headphones, snowmobile, manufacturing plant, lawnmower, hydraulic press, pneumatic drill	90 to 100
IRRITATING	dishwasher, computer room, subway, busy restaurant or kitchen	75 to 90
	city traffic, hair dryer, office equipment, cell phone	70 to 80
SAFE	normal conversation	50 to 70
	countryside with rustling leaves	20 to 50

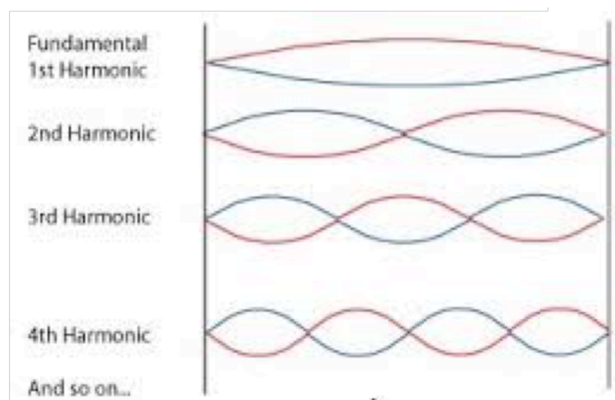
Standing Waves, Fundamental Frequency and Resonance

- Every elastic object has its own special _____________ frequency.
- When an object vibrates at its natural frequency, a __________ wave is produced, and the amplitude of the wave can get quite large.
- This phenomenon is called _____________.

- If you shake a spring with a fixed end, a standing wave can be created.
- The longest standing wave that can be created with this particular spring system would be __________ of a wave.

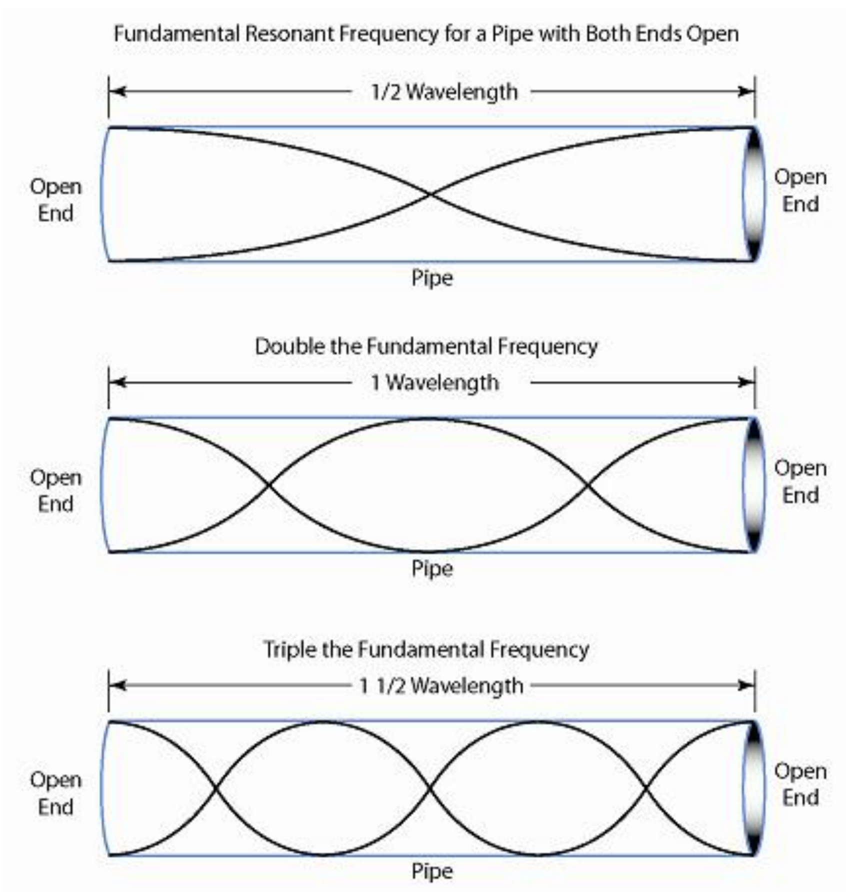


- The frequency that produces that wave is called the ___________ frequency.
- Standing waves (and therefore resonance) will occur whenever the frequency is a _____________ of the fundamental frequency. These are known as _____________ frequencies (or overtones).



Sound Quality of Musical Instruments

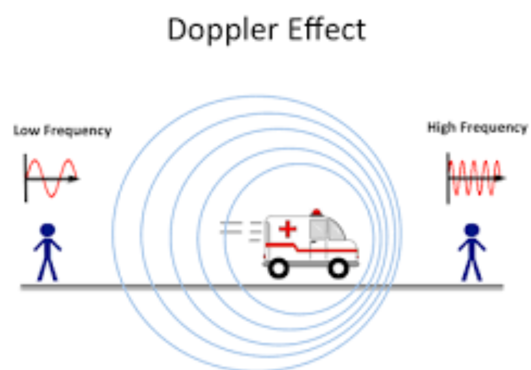
- If you blow just the right way into a tube (such as a graduated cylinder), you can get the tube to vibrate at its natural frequency and a _______ will be produced.
- Standing waves are produced in all musical instruments.
- Each instrument may produce the same _____________ (frequency), but the _____________ produced are different.
- The _ ____________of sound depends on the number of overtones produced and their relative loudness.



A great video for more info on standing waves in muslcal instruments:
https://www.youtube.com/watch?v=bHdHaYNX4Tk

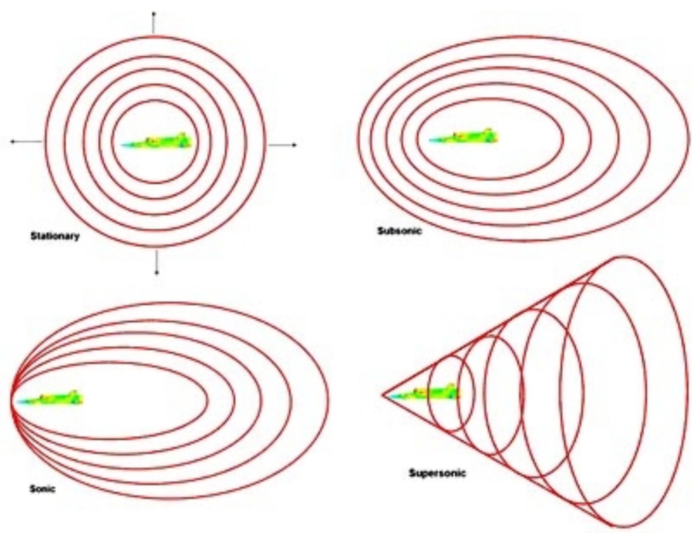
Doppler Shift

- change in ___________ resulting from movement of wave source i.e., change in pitch of ambulance siren as it approaches compared to when it moves away
- frequency of _______ doesn't change, but the waves are ___________ together as the source moves towards the receiver; therefore, the frequency of the ______________ wave is greater.



The Sound Barrier

- The speed of sound is approximately _______ m/s.
- If an object travels at the speed of sound, air _____________ at the front of the object, creating a '**sound barrier**'.



- If the object obtains enough thrust, it can break through the sound barrier a _____________ wave is produced called a **sonic boom**.

FORMAL LAB REPORTS

TITLE OF EXPERIMENT

Full Name
Date of Experiment
Block/Teacher

PROBLEM

The problem or purpose states exactly what we are trying to do or find out in the experiment.

HYPOTHESIS

An explanation of what we think will occur based on reasoning or observation; usually written as an If…then… statement.

PROCEDURE

Steps used to test your hypothesis or theory; a description of what we must do. Follow instructions in textbook or as instructed by your teacher. It is permissible to refer to an attached labsheet or text pages if there are no changes made.

DATA

This section is a record of all information collected during the procedures. Any set of measurements should be arranged in a table/graphs with headings. Where measurements are recorded, units must be stated. Provide drawings (in pencil unless computer-designed) where necessary and label all parts. Sketches should be simple line drawings. Describe all observations in point form.

DISCUSSION QUESTIONS

Number each question and answer in complete sentences. Underline any important words or phrases.

CONCLUSION

Answer questions stated in the problem. Summarize your discoveries and discuss your results further. Explain sources of experimental error.

GENERAL POINTS

- Write up lab in pen, drawings in pencil. Alternately, your lab may be typed and printed.
- Underline in contrasting colour (preferably red if in pen, or bolded if typed).
- Use a ruler for drawing tables, charts, underlining and drawing arrows.

MANIPULATING KINEMATICS EQUATIONS

Variable	$v_f = v_i + at$	$d = \frac{1}{2}(v_f + v_i)t$	$d = v_i t + \frac{1}{2}at^2$	$V_f^2 = v_i^2 + 2ad$
v_i				
v_f				
a				
d				
t				

Fundamental Constants and Physical Data

Universal Gravitational constant	$G = 6.67 \times 10^{-11}$ N.m²/kg²
Electric Current Data	$e = 1.60 \times 10^{-19}$ C $1C = 6.24 \times 10^{18}$ e $k = 9.00 \times 10^{9}$ Nm²/C²
Speed of light	$c = 3.00 \times 10^{8}$ m/s

Earth

radius	$r_e = 6.38 \times 10^{6}$ m
mass	$m_e = 5.98 \times 10^{24}$ kg
Acceleration due to gravity on surface (average)	$g = 9.81$ m/s² (N/kg)

Moon

radius	$r_m = 1.74 \times 10^{6}$ m
mass	$m_m = 7.35 \times 10^{22}$ kg

Prefix	Symbol	Fractions
pico	p	10^{-12} or 1/1 000 000 000 000
nano	n	10^{-9} or 1/1 000 000 000
micro	μ	10^{-6} or 1/1 000 000
milli	m	10^{-3} or 1/1 000
centi	c	10^{-2} or 1/100
deci	d	10^{-1} or 1/10
		Multiples
decka	da	10^{1} or 10
hector	h	10^{2} or 100
kilo	k	10^{3} or 1 000
mega	M	10^{6} or 1 000 000
giga	G	10^{9} or 1 000 000 000
tera	T	10^{12} or 1 000 000 000 000

Specific Heat Capacities

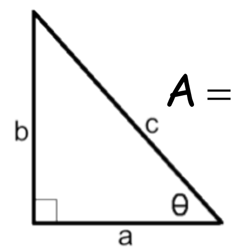
Substance	c/J kg⁻¹ K⁻¹	Substance	c/J kg⁻¹ K⁻¹
Aluminium	900	Ice	2100
Iron/steel	450	Wood	1700
Copper	390	Nylon	1700
Brass	380	Rubber	1700
Zinc	380	Marble	880
Silver	230	Concrete	850
Mercury	140	Granite	840
Tungsten	135	Sand	800
Platinum	130	Glass	670
Lead	130	Carbon	500
Hydrogen	14000	Ethanol	2400
Air	718	Paraffin	2100
Nitrogen	1040	Water	4186
Steam	2000	Sea water	3900

Right Triangles

$$a^2 + b^2 = c^2$$

$$\sin\theta = \frac{b}{c}$$

$$\cos\theta = \frac{a}{c}$$



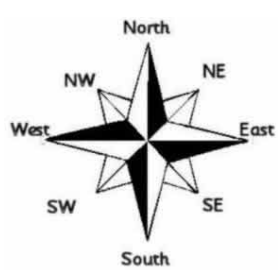
$$A = \frac{1}{2}ab$$

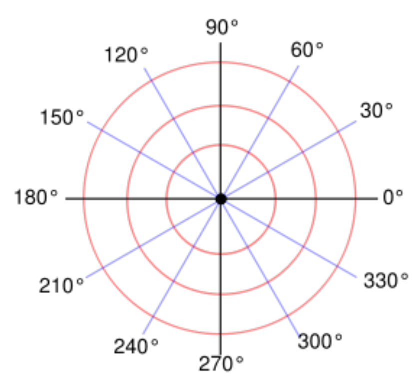
Circles

$$D = 2r$$

$$C = \pi D$$

$$A = \pi r^2$$





Kinematics

$$v_{ave} = \frac{\Delta d}{\Delta t} \quad a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

$$d = \left(\frac{v_i + v_f}{2}\right)t \quad v_f = v_i + at$$

$$d = v_i t + \frac{1}{2}at^2 \quad v_f^2 = v_i^2 + 2ad$$

Dynamics

$$F_g = mg$$

$$F_g = G\frac{m_1 m_2}{r^2} \quad F_a r_a^2 = F_b r_b^2$$

$$F_F = \mu F_N \quad F_E = k\Delta x$$

$$F_{net} = ma \quad p = mv$$

$$\Delta p = m\Delta v \quad \Delta p = F_{net}\Delta t$$

Energy

$$W = Fd \quad W = \Delta E$$

$$E_p = mgh \quad E_k = \frac{1}{2}mv^2$$

$$P = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t} \quad E_H = mc\Delta T$$

$$Eff = \frac{W_{out}}{W_{in}} = \frac{P_{out}}{P_{in}}$$

Electric Circuits

$$Q = ne \quad F = k\frac{Q_1 Q_2}{d^2}$$

$$I = \frac{Q}{t} \quad \Delta E = QV = VI\Delta t$$

$$V = IR \quad P = IV = I^2R = \frac{V^2}{R}$$

Series Circuits:

$V_s = V_1 + V_2 + V_3$

$I_s = I_1 = I_2 = I_3$

$R_s = R_1 + R_2 + R_3$

Parallel Circuits

$V_p = V_1 = V_2 = V_3$

$I_p = I_1 + I_2 + I_3$

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Special Relativity

$$f = \frac{1}{T} \quad v = f\lambda$$

$$\text{Sound Intensity} = \frac{P}{A} = \frac{\text{Watts}}{m^2}$$

$$\text{Ratio} = \frac{\text{Sound Intensity}}{\text{Sound Threshold}} = 10^n$$

(n = # bels)