Review of Grade 11 Physics: Part 1

If you want to do well in Physics this year – and beyond – you will need to remember the Physics concepts you learned last year (and in previous years). This first booklet contains 7 lessons that cover the essentials of the kinematics, dynamics, and energy units from grade 11. Tutorial assistance will be available after class if you need extra help.

The beginning of the last week of September, you will write a Review Quiz based on this material. To pass, you will need to get a mark of 70%. Students who expect to be successful in their university preparation studies should, with proper review, be able to easily meet this standard.

Review Lesson 1:

Graphing Motion: Info from position-time graphs

<u>Graphs of uniform motion (constant velocity)</u>

To calculate the velocity: $\vec{v}_{const}$ = slope of line = rise/run $= \dfrac{(\vec{d}_2 - \vec{d}_1)}{t_2 - t_1} \quad \left(= \dfrac{\Delta \vec{d}}{\Delta t}\right)$

<u>Graphs of non-uniform (changing) velocity</u>

average velocity: slope of secant between two points on a $\vec{d}$-t graph $\quad v_{avg} = \dfrac{d_2 - d_1}{t_2 - t_1} \left(= \dfrac{\Delta d}{\Delta t}\right)$

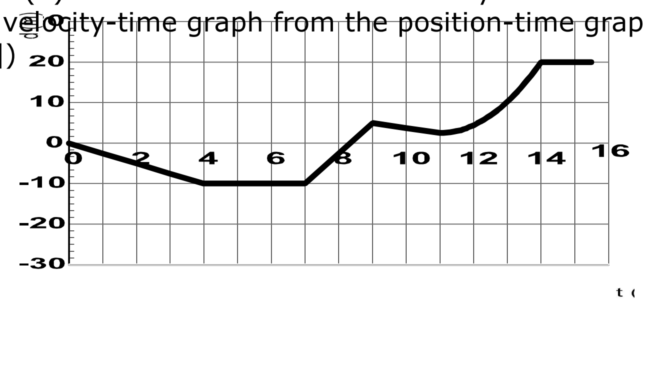
average speed: v_{avg} = total distance/total time = d_T / t_T

instantaneous velocity: slope of tangent at required point $\quad v_{inst} = \lim\limits_{\Delta t \to 0} \dfrac{\Delta d}{\Delta t}$

Note:
- The tangent touches the line at only one point
- $\vec{v}_{inst} \neq \dfrac{\vec{d}\text{ (at point)}}{t\text{ (at point)}}$ since that equals $\dfrac{\vec{d}\text{ (at point)} - 0}{t\text{ (at point)} - 0}$ = AVERAGE velocity from t=0 to t (at point)

1. Neelu is stopped at the light in her new Ferrari. When light turns green, she accelerates from rest for 3.0 s, reaching a speed of 9.0 m/s which is maintained for 5.0 s before decelerating and coming to a stop in the next 2.0 s. Sketch $\vec{d}$-t, $\vec{v}$-t, and $\vec{a}$-t graphs for Neelu's trip.

2. The following graph is that of an object moving in a straight line. East is considered as the positive direction. (a) Determine the position of the object after 7.0 s. (b) The graph shows five distinct sections. Briefly, and in general terms, describe the motion of the object in each of these sections. (c) Considering the whole journey, calculate the average velocity. (d) Find the instantaneous velocity at t = 13s. (e) Using an appropriate scale, draw a velocity-time graph from the position-time graph. (10. m [W], 1.3 m/s [E], 6.0 m/s [E])



Review lesson 2:

Graphing Motion: Info from velocity-time graphs

To calculate the acceleration: $\vec{a}_{const}$ = slope of line on $\vec{v}$-t graph= rise/run

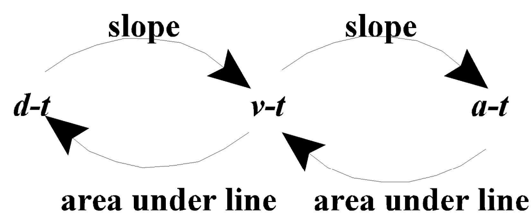
$$= \frac{(\vec{v}_2 - \vec{v}_1)}{t_2 - t_1} \qquad \left(= \frac{\Delta \vec{v}}{\Delta t}\right)$$

average acceleration: slope of secant between two points on $\vec{v}$-t graph $a_{avg} = \dfrac{v_2 - v_1}{t_2 - t_1} \quad \left(= \dfrac{\Delta v}{\Delta t}\right)$

instantaneous acceleration: slope of tangent at required point on $\vec{v}$-t graph $a_{inst} = \lim\limits_{\Delta t \to 0} \dfrac{\Delta v}{\Delta t}$

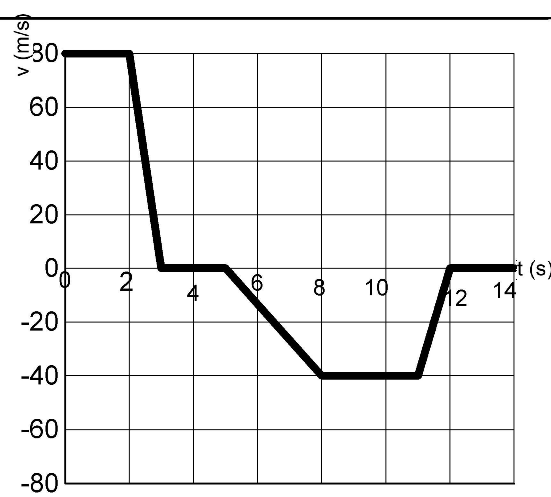
Displacement from $\vec{v}$-t graphs: $\Delta \vec{d}$ = area under line on $\vec{v}$-t graph between two points in time

<u>Going between graphs</u>

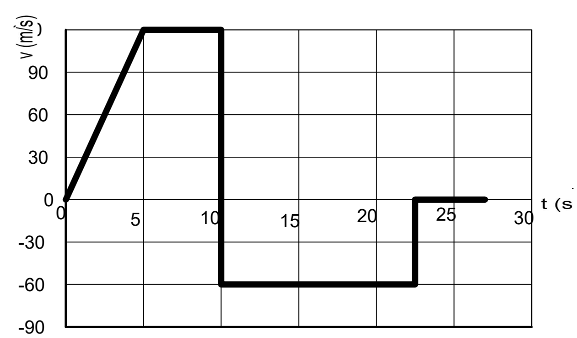


1. This velocity-time graph describes the motion of an object moving in a straight line. At the beginning it is going east. From the graph, determine each of the following.
   a. The object's displacement in the first 3.0 s
   b. The object's displacement between t = 3.0 s and t = 5.0 s
   c. The total displacement of the object in 14 s
   d. The average velocity of the object from t = 0 to t = 8.0 s
   e. The *d-t* graph; use it to check your answers to parts (a) to (d).

   (200 m [E], 0, 0, 17.5 m/s [E])

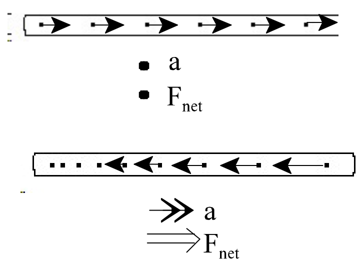


2. Use this graph of the motion of a car to find the total displacement (north is positive). (150 m [N])



Review lesson 3:

Motion Dot Diagrams
(aka Ticker Tape or Oil Drop Diagrams)



- A long tape is attached to a moving object and threaded through a device that places a tick upon the tape at regular intervals of time.
- The distance between dots on a motion dot diagram represents the object's position change during that time interval.
- A changing distance between dots indicates a changing velocity
- include the velocity vectors at each point
- use a double-headed arrow to indicate acceleration
- use a double-lined arrow to indicate net force

1. Sketch the motion dot diagrams for an object that is
   a. Moving slowly right uniformly
   b. Moving quickly left uniformly
   c. Speeding up to the right
   d. Slowing down to the right
   e. Speeding up to the left
   f. Slowing down to the left.

2. Sketch the motion dot diagrams for each question in review session #1.

Review lesson 4:

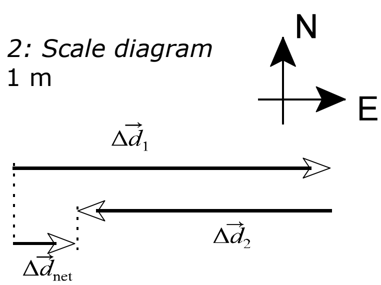
Vectors and 2D Motion

<u>Vector addition using collinear vectors</u> (vectors which are on the same line)
Ex: Victor Vector walks for a displacement of 5.0 m [E] then 4.0 m [W]. What has his resultant displacement?

Method 1: Calculation

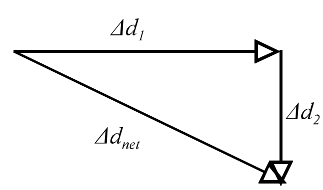
$\Delta \vec{d}_{net} = \Delta \vec{d}_1 + \Delta \vec{d}_2$
$= 5.0$ m [E] + 4.0 m [W]
$= 5.0$ m [E] - 4.0 m [E]
$= 1.0$ m [E]

Method 2: Scale diagram
1 cm = 1 m



<u>Vector addition using non-collinear vectors</u>

- Using scale diagrams, draw the vectors consecutively, connecting them tips to tails
- Then, measure the resultant vector (magnitude and direction)
- You can also use trig formulas and the Pythagorean theorem



1. *To get to the cafeteria entrance, a certain math teacher walks 34 m [N] in one hallway, and then 46 m [W] in another hallway. The entire motion takes 1.5 min. Using both trigonometry and scale diagrams, determine the teacher’s (a) resultant displacement, (b) average speed, and (c) average velocity. (57 m [N54°W], 0.89 m/s, 0.64 m/s [N54°W])

Review lesson 5:

Kinematics

Uniform Motion ($\vec{a}$ = 0): $v = \frac{\Delta d}{\Delta t}$ NOTE: do **not** use this equation when $\vec{a} \neq 0$.

Non-uniform Motion ($\vec{a} \neq 0$): The Big 5 Equations of Kinematics/Motion

$$v = u + a\Delta t$$

$$\Delta d = \tfrac{1}{2}(v + u)\Delta t$$

$$\Delta d = u\Delta t + \tfrac{1}{2}a\Delta t^2$$

NOTE: these equations only work for **constant** acceleration

$$\Delta d = v\Delta t - \tfrac{1}{2}a\Delta t^2$$

$$v^2 = u^2 + 2a\Delta d$$

acceleration due to gravity: $\vec{g}$ = 9.8 m/s^2 [down]

Answer the following kinematics problems. Use the 4-box solution structure.

1. A badminton shuttle, or "birdie," is struck, giving it a horizontal velocity of 73 m/s [W]. Air resistance causes a constant acceleration of 18 m/s^2 [E]. Determine its velocity after 1.6 s. (44 m/s [W])

2. A baseball travelling horizontally at 41 m/s [S] is hit by a baseball bat, causing its velocity to become 47 m/s [N]. The ball is in contact with the bat for 1.9 ms, and undergoes constant acceleration during this interval. What is that acceleration? (4.6 x 10^4 m/s^2 [N])

3. Upon leaving the starting block, a sprinter undergoes a constant acceleration of 2.3 m/s^2 [fwd] for 3.6 s. Determine the sprinter's (a) displacement and (b) final velocity. (15 m [fwd], 8.3 m/s [fwd])

4. An electron travelling at 7.72 x 10^7 m/s [E] enters a force field that reduces its velocity to 2.46 x 10^7 m/s [E]. The acceleration is constant. The displacement during the acceleration is 0.478 m [E]. Determine (a) the electron's acceleration and (b) the time interval over which the acceleration occurs. (5.6x10^{15} m/s^2 [W], 9.39x10^{-9} s)

5. A certain physics teacher is frustrated with Mac computers, so she throws one straight up from the top of a 50.-m tall building. The computer's initial velocity is 20. m/s [straight up]. Find (a) the maximum height of the computer, (b) the amount of time it takes to reach that height, (c) the amount of time it takes the computer to reach the ground, and (d) the final velocity of the computer as it hits the ground. (70. m, 2.0 s, 5.8 s, 37 m/s [down])

Dynamics

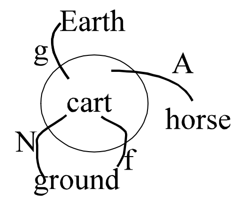
A force is a push or a pull. It is a vector quantity and is measured in newtons (1 N = 1 kg m/s^2). Often several forces will be acting on an object. The **net force** $\vec{F}_{net}$ can be found using vector addition. If the net force is 0, then the object will remain at rest or continue moving with constant velocity.

Newton's Laws of Motion

1. Every object maintains its state of rest or uniform motion unless acted upon by an external unbalanced force.
2. $\vec{F}_{net} = m\vec{a}$
3. $\vec{F}_{A \text{ on } B} = -\vec{F}_{B \text{ on } A}$ (For every action force there is an equal but opposite reaction force)

Common forces

- $\vec{F}_g$: force of gravity – the force of attraction due to mass ($\vec{F}_g = m\vec{g}$)
- $\vec{F}_N$: normal force - the force exerted on the object, perp. to the surface it is on
- $\vec{F}_f$: force of friction - acts in opposite direction to dir. of motion or intended motion
- ($F_f = \mu F_N$ where μ is the coefficient of friction in N/N)
- $\vec{F}_A$: applied force



Interaction diagrams

- circle contains all objects in the system
- all objects interacting with the system are outside the circle
- lines connecting objects and system for each force, labelled

Force diagrams (Free Body Diagrams aka FBDs)

- Draw the directional compass; dir. can include up, down, fwd, back, N, S, E, W, etc.
- Draw a box representing the object
- Locate, approximately, the centre of mass (balance point) of the object
- From the point, draw a force vector to represent each force acting only **on** the object. The vectors should be to scale.

1. A child is pulling on a wagon with a force of 10 N [W]. If the force of friction is 6 N and the cart has a mass of 0.8 kg, (a) draw the interaction and force diagrams of the wagon, (b) find the net force on the wagon, (c) find the weight of the wagon, and (d) find the acceleration of the wagon. (4 N [W], 8 N [down], 5m/s^2 [W])

2. Alysha is pulling a seriously sticky125 g doughnut to the right across a table. The coefficient of friction between the table and the doughnut is 0.75 N/N. If the doughnut is accelerating at 1.4 m/s^2 to the left, use the 4-box solution structure to predict all the forces acting on the doughnut. (F_g = 1.2 N [down], F_N = 1.2 N [up], F_f = 0.92 N [left], F_A = 0.74 N [right])

3. Use the 4-box solution structure. What is the net force on a curling stone of mass 18 kg that comes to rest after 15 s from an initial velocity of 3.0 m/s? What is the coefficient of friction between the stone and the ice? (3.6 N [back], 0.020 N/N)

4. Two boys, one with a mass of 60 kg and one with a mass of 90 kg, are standing side by side on an ice rink. One of them pushes the other with a force of 360 N for 0.10 s. Assuming that the ice is frictionless, use the 4-box solution structure to predict (a) what is acceleration of each boy, (b) what speed will each reach after 0.10 s, (c) how far apart are they after 0.10 s, and (d) does it matter who does the pushing? (6.0m/s^2 [⇐], 4.0m/s^2 [⇒], 0.60 m/s [⇐], 0.40 m/s [⇒], 0.50 m)

5. Use Newton's Laws to explain the following situations: (a) Many novice hunters have experienced a sore shoulder after firing a shotgun, (b) subway cars provide posts and overhead rails for standing passengers.

Review lesson 7:

Work, Energy, Power

Work (W) is the transfer of energy from one object to another. $W = F\Delta d$
The unit of work is the joule (1 J = 1 N m = 1 kg m^2/s^2)

Conditions for work to be done on an object

- A force must be exerted on the object
- The object must be displaced by the force
- The net force must be in the same direction as the displacement

Energy (E) is the ability to do work. The unit of energy is also the joule.

- **The Law of Conservation of Energy**: Energy cannot be created or destroyed, but only converted from one form to another
- The total energy at one point is equal to the total energy at any other point.
- Work is done when mechanical energy is transferred from one object to another ($W = \Delta E_T$)
- Energy comes in many forms which are interchangeable
- Energy can be stored to do work later

Energy Types:

Potential energy - energy stored in an object, e.g. chemical, nuclear, gravitational, elastic

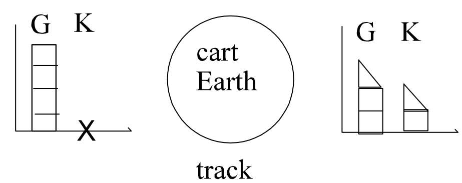
Gravitational Potential Energy $E_g = mgh$
– the energy stored in an object due to its height above a ref. point.

Kinetic energy - energy of motion, e.g. sound, heat, radiant, bulk kinetic, electrical

(Bulk) Kinetic Energy $E_k = ½ mv^2$
– the energy possessed by an object due to its motion

LOL diagrams

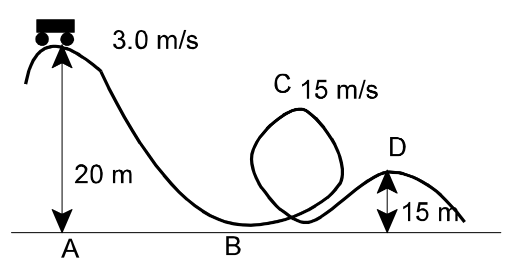
- demonstrate the transformation of energy
- L: how energy is stored at that instant
- O: show objects inside and outside the system
- 4 blocks per L; half blocks shown as right triangles; X on axis for no energy
- the math comes from the diagrams



$$E_{T_1} = E_{T_2}$$
$$E_{g_1} + E_{k_1} = E_{g_2} + E_{k_2}$$

Power ($P = W/\Delta t = \Delta E/\Delta t$) is the amount of work done over time. The unit of power is the watt (1 W = 1 J/s)

1. How much work is done by an elevator lifting 10 people with an average mass of 67 kg to a height of 40. m? (2.6×10^5 J)



2. Consider the roller coaster at right. Sketch the LOL diagrams. How fast will the car be travelling at B, D? What is the height at C? Assume there is no friction. (20. m/s, 10. m/s, 9.0 m)

3. A hockey puck hits the crossbar of the net with a speed of 14 m/s and is deflected straight up. Sketch the LOL diagrams. How high will it go? (10. m)

4. A slingshot shoots a stone of mass 0.025 kg. An average force of 27 N is applied over 0.15 m to release it. Draw the LOL. How fast is it travelling upon release? (18 m/s)

5. How long does it take the 9.0×10^3 W elevator in question 1 to lift its passengers? (29 s)

4-box Solution Structure

You need to be able to represent the problem in multiple ways. The picture/word representation drives the physics, which drives the math.

Kinematics solution

1. Picture and word description of motion	2. Physics representation: motion dot diagrams, d-t, v-t, and a-t graphs
3. Mathematical representation, including units	4. Prediction I predict that...

Dynamics solution

1. Picture and word description of motion	2. Physics representation: motion dot diagrams, interaction diagram, force diagram
3. Mathematical representation, including units	4. Predictions I predict the ...