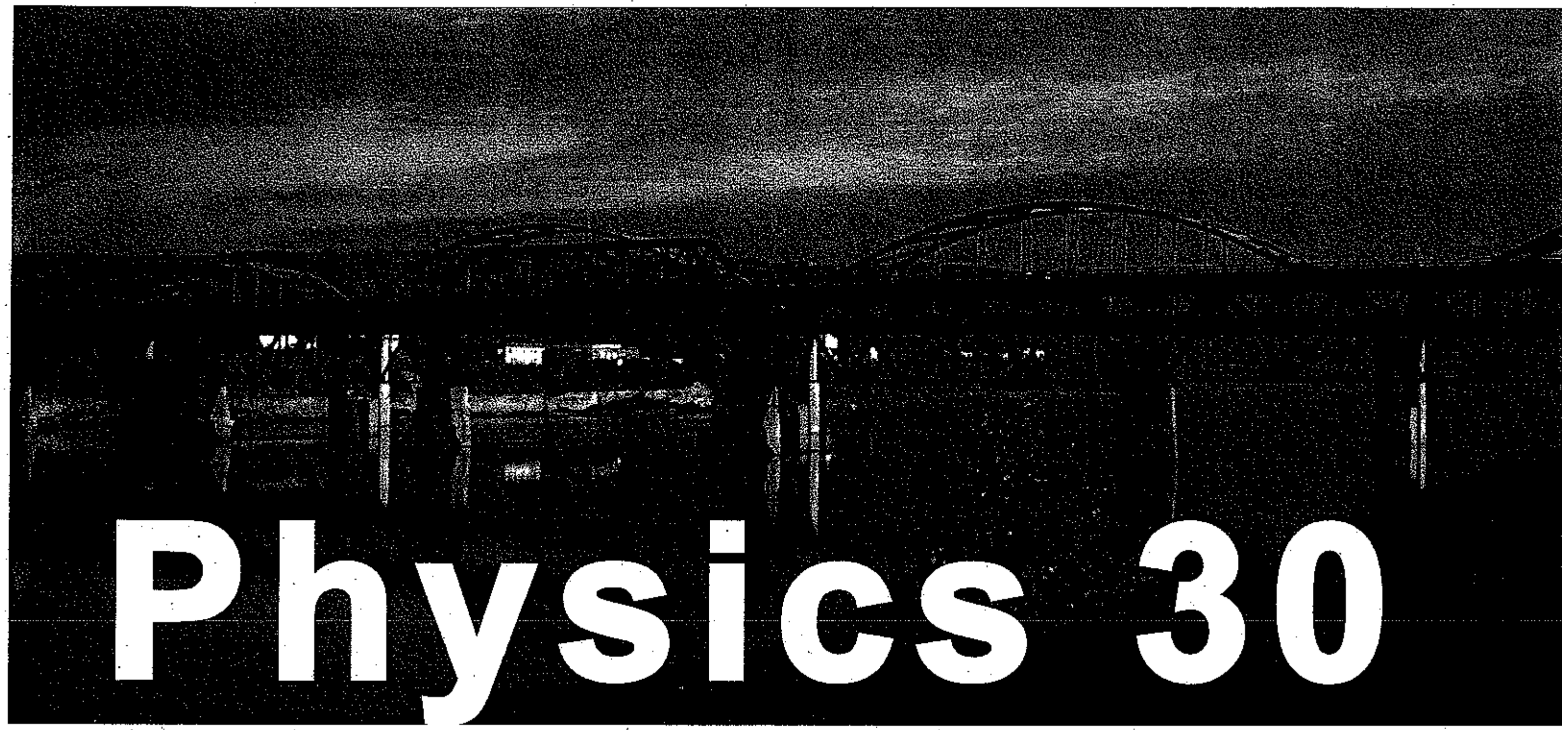
Key



Diploma Review

This booklet summarizes your Physics 30 course and gives you helpful tips to prepare you to write your Physics 30 diploma exam.

Tips,

Tricks,

& helpful

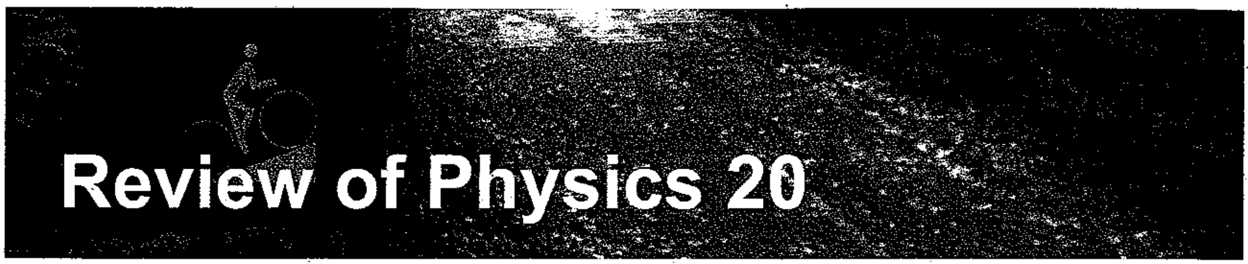
Hints

The Physics 30 Diploma Exam will be written:

Date: ____________________

Time: ____________________

Location: ____________________



Review of Physics 20

Measurement

All measurements contain some estimation — no measurement is perfect. The number of significant digits will communicate the quality of a measurement.

Units

Memorize the four fundamental units and the common derived units.

1. Answers must always have appropriate units. Complete the chart below by writing in the name of the unit.

Answers for all questions are on page 42.

Fundamental units	Derived units
(m) for distance	(N) for force
(s) for time	(J) for work or energy
(kg) for mass	(W) for power
(A) for current	(C) for charge
	(T) for magnetic field
	(V) for potential difference

Charts

The manipulated variable should be in the first column; the responding variable should be in the second column.

Voltage (V)	Current (mA)
2.0	6.3
4.0	12.5
6.0	18.8

Vectors & Scalars

Vectors have both magnitude (size) and direction. **Scalars** have magnitude only.

2. Construct a list of scalars and vectors.

Scalars	Vectors
speed	velocity
distance	displacement
time	acceleration
work / energy	gravity field
temperature	electric field
mass	magnetic field
charge	momentum
voltage	impulse

Indicating vector direction:

- use +/– for linear

3. A ball is travelling at 9.0 m/s to the north when it collides with a window. Determine the ball's change in velocity if it
   a. breaks the window and continues to travel to the north at 4.0 m/s.
   b. bounces off the window and travels south at 4.0 m/s.

a) $\Delta\vec{v} = v_f - v_i$

$= 4.0 - 9.0$

$= -5.0\ m/s$

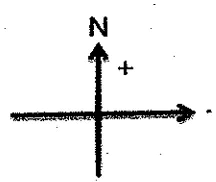
b) $\Delta\vec{v} = v_f - v_i$

$= -4.0 - 9.0$

$= -13\ m/s$

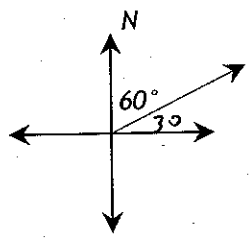
2-D Direction

Use a compass rosette for geographic references.



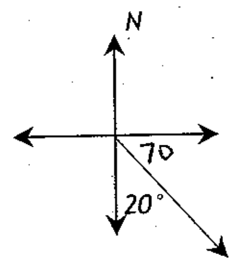
4. State the direction indicated by the following vectors.

a.



60° E of N
30° N of E

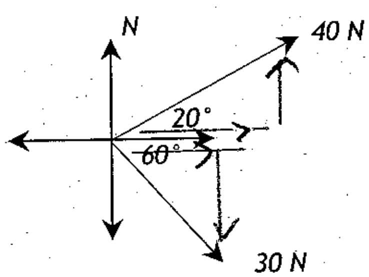
b.



20° E of S
70° S of E

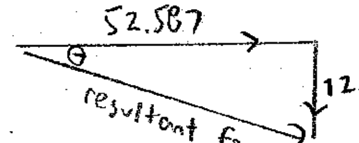
Especially for multiple choice questions, a scale diagram may obtain an answer for a non-right angle vector question much faster than using components.

5. Two forces act on a mass as shown in the free-body diagram below. Determine the net force.



method 1 - add components

X	Y
$(\cos 20 \times 40) + (\cos 60 \times 30)$	$(\sin 20 \times 40) + -(\sin 60 \times 30)$
$37.587.. + 15$	$13.68.. + -(25.981..)$
$52.587..$ N	-12.3 N



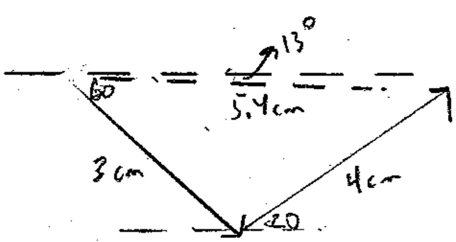
$c = \sqrt{(52.587)^2 + (12.3)^2}$

$= 54.01$ N

(54 N)

$\tan\theta = \frac{12.3}{52.587}$ = (13° SE)

method 2 - scale diagram (need protractor)



54 N [13° SE]

add tip to tail

Scale 1cm = 10 N

Free-body Diagrams

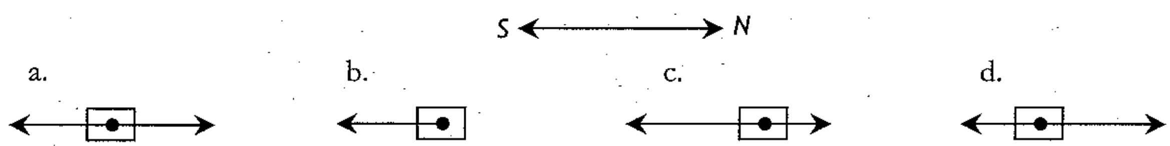
Free-body diagrams are used to communicate forces acting on an object and are a necessary part of showing your work in questions involving forces.

How to draw free-body diagrams.

- Draw the object (or a simple shape representing the object) without any surrounding objects.
- Use arrows to represent forces acting on the object. Label them.
- The length of an arrow represents the relative magnitude of the force.
- Do not draw a net force or acceleration arrow on the object.

Use the information below to answer question 6.

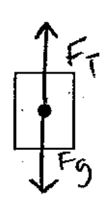
Four different free-body diagrams are drawn below.



6. Identify the free-body diagram(s) that represents forces causing the object to be:
   A. in constant motion. a – net force is ∅
   B. accelerating to the north. d – net force is north
   C. given a net force to the south. b and c net force is south
   D. stationary. a – net force is ∅

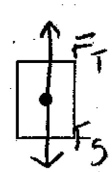
7. Use free-body diagrams when describing forces. Draw a free-body diagram for an elevator that is:

   a. stationary.



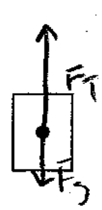
$F_T = F_g$

   b. moving downwards at a constant velocity. → no F_{net}!



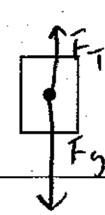
$F_T = F_g$

   c. accelerating upwards.



$F_{net} = F_T - F_g$

   d. accelerating downwards.



$F_{net} = F_g - F_T$

Graphing

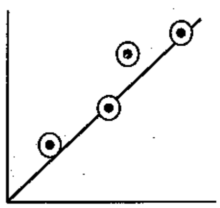
- The title should be in the form responding variable vs. manipulated variable.
- Draw best-fit lines or curves as required.
- Never force your line to go through zero (the origin) even if it theoretically should go through the zero.

For calculating slope of a straight line:

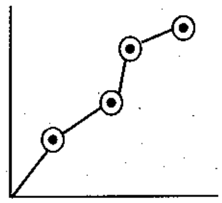
$$slope = \frac{y_2 - y_1}{x_2 - x_1}$$

8. Identify the graph showing the properly drawn best-fit line.

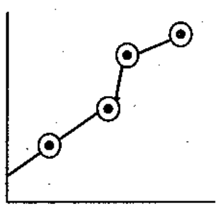
A.



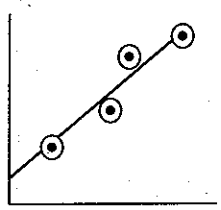
B.



C.



D.



Physics 30 Review

Graphical Analysis

When presented with the need to analyze a graph, follow these steps.

1. Identify the responding and manipulated variables.
2. Identify a formula that contains the manipulated and responding variables.
3. Isolate the responding variable.
4. Identify the slope as anything multiplying and/or dividing the manipulated variable.

$$y = mx + b$$

When the responding variable is graphed against the modified manipulated variable a straight line will result. Sometimes the responding variable has to be modified.

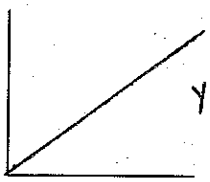
Curve Straightening

Once the responding variable is isolated, note what is happening to the manipulated variable. Carry out this operation on each of the manipulated data and re-graph to get a straight line.

9. Sketch the graphs and provide the general formula for each of the following relationships.

a. linear

note y int is not always $\emptyset, \emptyset$

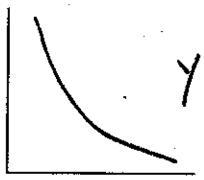


$y = mx + b$

b. parabolic

$y \propto x^2$

c. inverse



$y \propto \frac{1}{x}$

d. inverse square

$y \propto \frac{1}{x^2}$

Procedure for making a curved line straight.

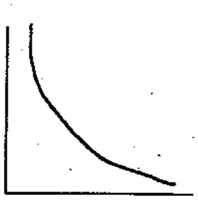
- Isolate the responding variable.
- Recognize what is happening to the manipulated variable (e.g., is it squared or inversed).
- Modify (square it or inverse it) the manipulated variable and place the modified numbers in a new column.
- The modified variables are plotted to give the linear graph (also modify the units in the same way).

10. An experiment is done to determine the value of Coulomb's constant, k. The distance between two charge spheres are manipulated and the corresponding electrostatic force is measured.

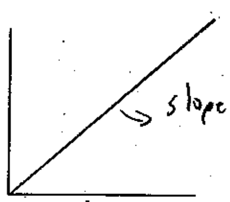
$F_{el} = \frac{k q_1 q_2}{R^2}$

a. Sketch the expected graph when electrostatic force is plotted as a function of separation distance.
b. Identify what must be plotted in order to obtain a straight line. Sketch the line.
c. Show how the straight line graph could be used to determine the value of Coulomb's constant.

a.



b.



slope $= \frac{F_{el}}{\frac{1}{R^2}}$

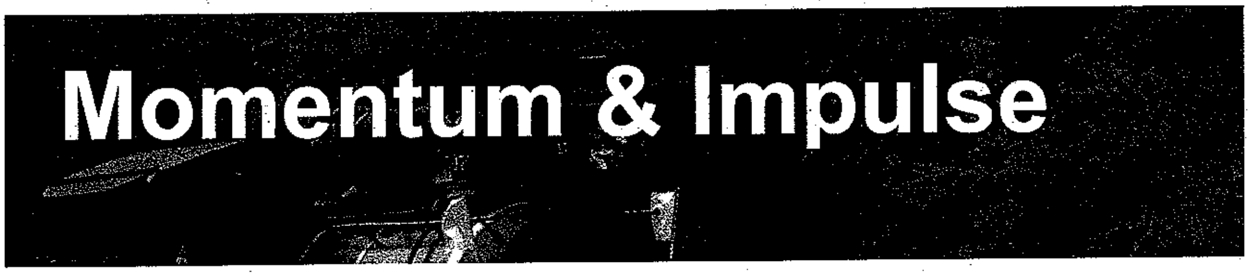
slope $= F_{el} \cdot R^2$

c.

$F_{el} = \frac{k q_1 q_2}{R^2}$

slope $= k q_1 q_2$

$\frac{\text{slope}}{q_1 q_2} = k$

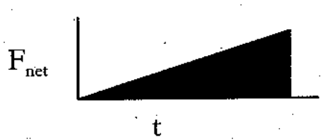


Momentum & Impulse

Major points

- Linear collisions: use +/– signs for direction.
- Energy is transformed from one type to another; momentum is transferred from one object to another.
- An isolated system has no interactions (exchange of energy, mass or forces) with other systems.
- **Impulse** of an object is its change in momentum.

- The area under a net force versus time graph is impulse.



Collision types:

- elastic collision — kinetic energy and momentum are conserved
- inelastic collisions — only momentum is conserved

Tips

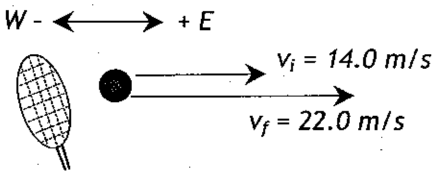
- Two-dimensional collisions must involve trigonometry.

- When asked to explain any question involving momentum, make sure to state that **momentum is conserved.**

- Use $Ft = m\Delta v$ to help explain how increasing the time of impact decreases the force of impact, thus limiting damage. This can be used to explain concepts, such as air bags, bungee cords, trampolines, crumple zones in cars, and many other collisions.

- To show that a collision is either elastic or inelastic, compare the total kinetic energy before to the total kinetic energy after. Kinetic energy is conserved only in elastic collisions.

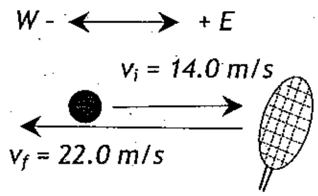
11. A 42 g racquetball is moving east at 14.0 m/s when it is struck by a racquet giving it a velocity of 22.0 m/s east. Determine the impulse given to the ball.



Impulse = Δp
$= m\Delta v$
$= m(v_f - v_i)$
$= 0.042(22 - 14)$
$= 0.34$ kg·m/s or N·s

impulse = 0.34 N·s East

12. A 42 g racquetball is moving east at 14.0 m/s when it is struck by a racquet giving it a velocity of 22.0 m/s to the west. Determine the impulse given to the ball.



impulse = Δp
$= m(v_f - v_i)$
$= 0.042(-22 - 14)$
$= -1.5$ kg·m/s

Impulse = 1.5 N·s West

13. High jumpers must land on soft mats to avoid injury. Use physics terminology and formulae to describe how the soft mat works to prevent injuries.

Whether you fall on the mat or the ground you experience the same impulse

ground: $F\Delta t = \Delta p$ — small stopping time means large force

soft mat: $F\Delta t = \Delta p$ — long stopping time means less force.

14. Two objects, A and B, are on a head-on collision course. Object A's mass is 2.0 g and it is travelling at 12.0 m/s to the right. Object B's mass is 4.0 g and it is travelling at 3.0 m/s to the left. After the collision, object A is travelling to the right at 1.5 m/s. The velocity of object B after the collision is:

A. 2.3 m/s to the right.
B. 2.3 m/s to the left.
C. 8.3 m/s to the right.
D. 8.3 m/s to the left.

This is a 1D collision (don't stick)

$p_b = p_a$

$m_A v_A + m_B v_B = m_A v_A' + m_B v_B'$

$(2.0 \times 12) + (4.0 \times -3.0) = (2.0 \times 1.5) + 4.0 \times v_B'$

$24 + -12 = 3.0 + 4.0 v_B'$

$\frac{+12 - 3.0}{4.0} = v_B'$

2.25 m/s $= v_B'$

2.3 m/s right $= v_B'$

Forces & Fields

Fields are the space around an object that can be influenced by that object. The effect produced is a force. You have studied three types of fields in Physics 30.

Field	Source/cause	Direction	Range	Test object
Gravitational (g)	mass	attraction only	infinite	small mass
Electric (|E|)	charge	attraction & repulsion	infinite	small positive charge
Magnetic (B)	moving charges	attraction & repulsion	infinite	compass needle

Electrostatics

Major points

- Charge is conserved.
- There are two types of charges, positive and negative. A neutral object contains equal amounts of both.
- **Law of Electric Charge**: like charges repel; unlike charges attract.
- Conduction is the transfer of charge.
- Induction is the separation of charge due to another near-by charge (no contact).

There are three ways to charge an object:

- by conduction (e.g., contact) — produces identically charged objects.
- by friction — produces oppositely charged objects.
- by induction — produces oppositely charged objects.

Coulomb's law describes the electrostatic force between two charged objects.

$$F_e = \frac{kq_1q_2}{r^2}$$

Tips

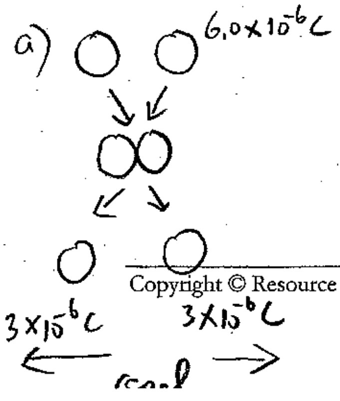
- Do not forget to square the distance in Coulomb's law formula.
- Do not confuse spring constant "k" with Coulomb's constant "k." They are totally different.

15. Two point charges produce an electrostatic force of attraction of 5.5 mN. Determine the electrostatic force produced if the charge on both objects is doubled and the distance between them is tripled.

$F_{el} = \frac{kq_1q_2}{r^2}$ $\quad F_{el} \propto \frac{q_1q_2}{r^2} \propto \frac{(2)(2)}{(3)^2} \propto \frac{4}{9} \times \text{original } (5.5\text{ mN}) = 2.4\text{ mN}$ or $2.4\times10^{-3}\text{ N}$

16. Two identical metal objects, one neutral and the other with a charge of +6.0 μC, are brought into contact and then separated to a distance of 0.20 m.
    a. Is the force between the objects attractive or repulsive after contact?
    b. Calculate the magnitude of the electrostatic force between the two charged objects.

a)



b) $F_{el} = \frac{kq_1q_2}{r^2} = \frac{k(3\times10^{-6})^2}{(0.20)^2} = 2.0\text{ N}$

each sphere repels the other with an F_{el} of 2.0 N

Electric Fields

Major points

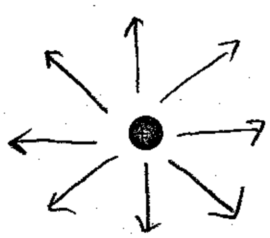
- The direction of an electric field is defined as the direction a small positive charge (test charge) would move when placed in the field.
- A test charge may be defined as an imaginary positive charge placed in the field.
- To determine electric field direction, ask the question: "Which way would a positive charge move?" The direction of movement is the direction of the field.

Tips

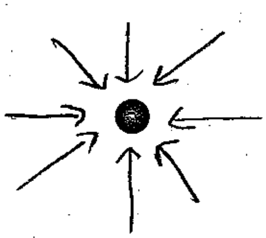
- Don't confuse E for energy and E for electric field. They may be used in the same solution and are often mixed up.
- Force and field are often confused. Be careful not to confuse the two. (Often students solve for an electric force when the question asks for electric field.)
- $|E| = \frac{kq}{r^2}$ is used only for point charges, not parallel plates.
- $F_e = q|E|$ works for all situations.

17. Draw the electric field pattern for each situation below.

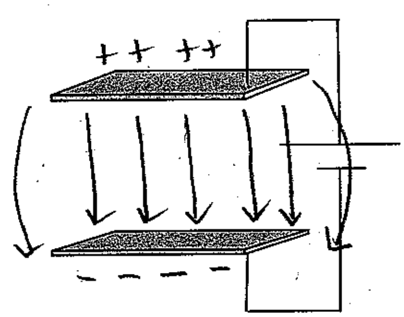
a. Positive point charge



b. Negative point charge



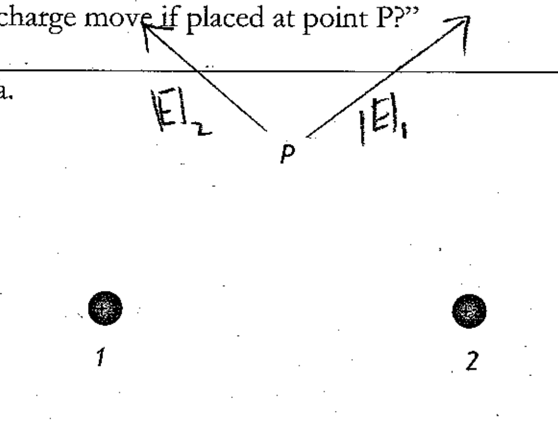
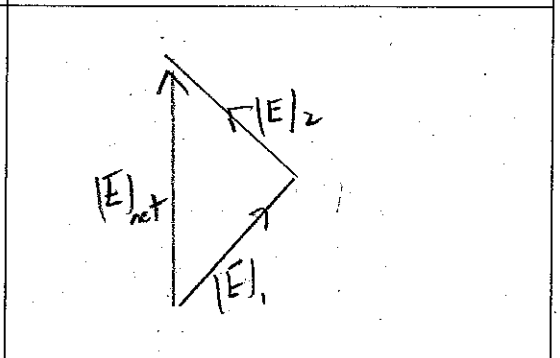
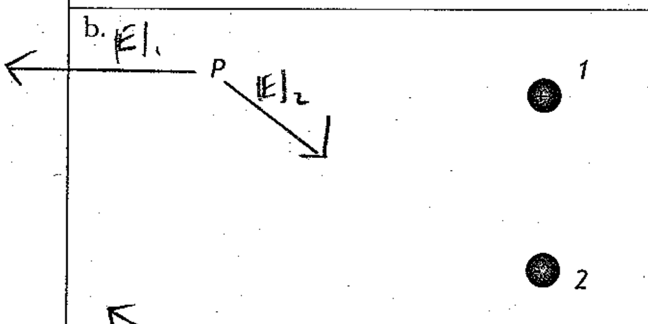
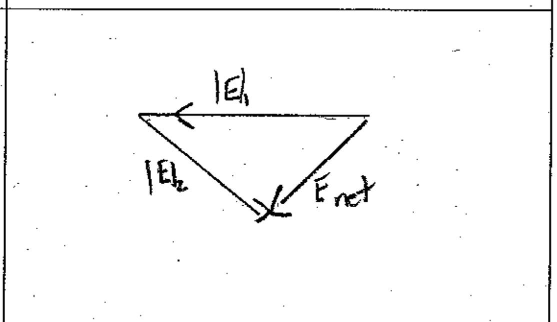
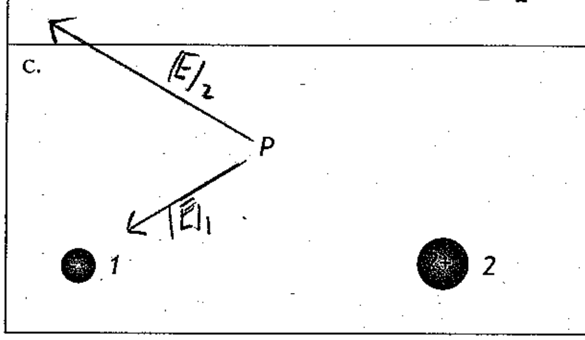
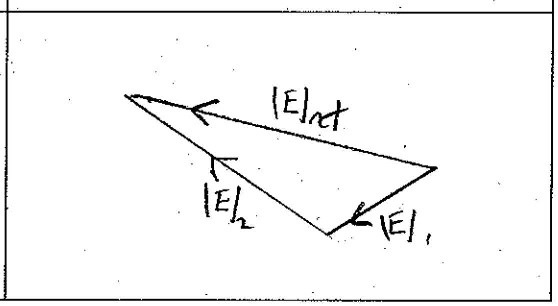
c. Parallel plates



non-uniform electric fields

uniform electric fields

18. Complete the two columns below. In the first column, sketch vector arrows representing the electric field at point P as a result of each of the two charges. In the second column, sketch the head-to-tail vector diagram. The arrow length should represent the relative magnitudes of the vectors.

Individual Vectors	**Head-to-tail Vector diagram**
Ask: "What direction would a positive charge move if placed at point P?"	The net electric field is the vector sum of the individual fields.
a. 	
b. 	
c. 	

remember $|\vec{E}| \propto q$

$|\vec{E}| \propto \frac{1}{R^2}$

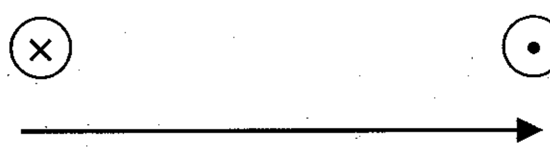
Magnetism

Major points

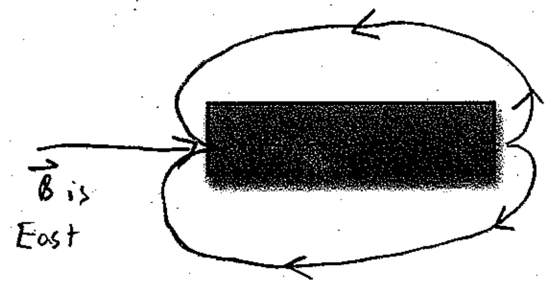
- Moving charges create magnetic fields.
- A charged particle moving through an external magnetic field experiences a force ($F_m = qvB$).
- Magnetic field direction is determined by the direction the north end of a compass points (i.e., from the north pole to the south pole on the outside of a magnet).
- **Motor effect** – A current-carrying wire inside a magnetic field will experience a force. ($F_m = BI\ell$)
- **Induction** (generator effect) – A wire that is forced to move through a magnetic field will produce a current. The current produces its own magnetic field that opposes the original magnetic field (Lenz's Law).
- Use your left hand for negative charges and your right hand for positive charges (conventional current).

- A compass needle is deflected perpendicular to a current carrying wire.
- The compass shows the direction of the magnetic field (B).
- The direction of current flow will affect the direction of the magnetic field.
- The vector convention is:

vector into the page vector out of the page



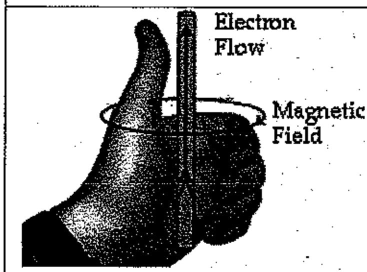
19. Identify the magnetic field direction to the left-hand side of the bar magnet shown below.

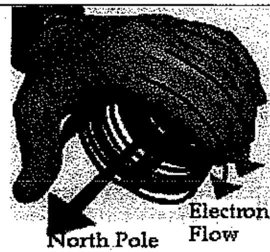


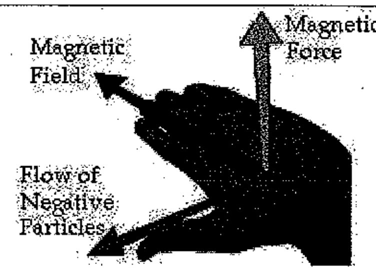
Hand Rules

Hand rules relate current direction with magnetic field direction. Use your left hand for negative charges and your right hand for positive charges.

First left-hand rule for electron flow through a **straight wire.**	Second left-hand rule for electron flow through a **coil.**	Third left-hand rule for the flow of negative particles through a magnetic field or electrons through a wire. Charged particles will turn in a circle as they move through a magnetic field.







Tips

- Electric charges and magnetic poles are different phenomena. Positive and negative charges are NOT attracted to, or repelled from, north and south poles.
- Know your hand rules. The hand rules help determine the relationship between current, magnetic field and magnetic force.
- A mass spectrometer (charged particle through a magnetic field) can be used to determine the mass of charged particles.
- Be able to derive the expression for the speed of a charged particle through a velocity selector.

20. A beam of singly ionized lithium ions is not deflected as it passes through a velocity selector having a magnetic field strength 1.8×10^{-3} T perpendicular to an electric field of 500 N/C towards the ground.
    a. Draw a free-body diagram of a lithium ion as it passes through the fields.
    b. Determine the speed of the ions.

a) undeflected so...

↑ F_e

↓ F_m

b) $F_e = F_m$

$q|\vec{E}| = qvB_\perp$

$\frac{500}{1.8\times10^{-3}} = \vec{v}$

$2.8\times10^{5}\ \frac{m}{s} = \vec{v}$

Wave Nature of EMR

Energy may be transported by the movement of particles or by waves (vibration of a substance).

Major points

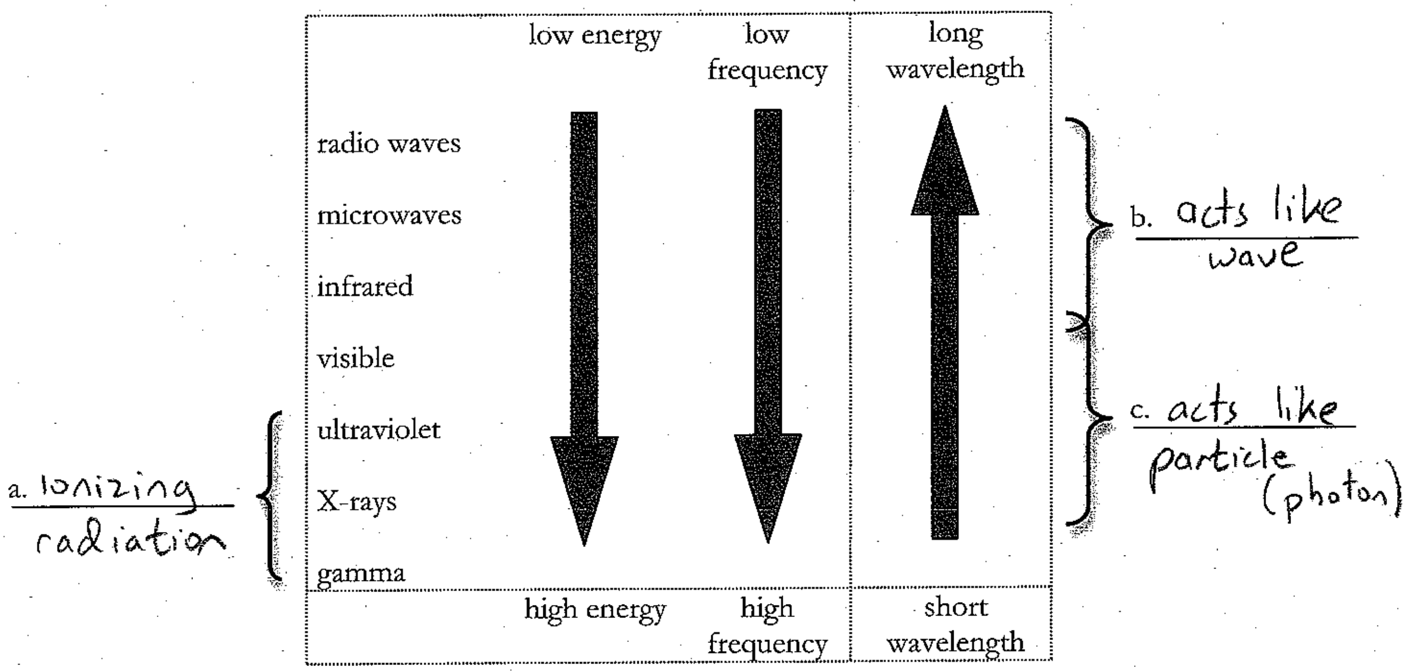
- Accelerating charges produce electromagnetic radiation (EMR).
- For certain behaviours EMR must be thought of as a wave.
- Diffraction and interference can be explained by assuming light is a wave.
- The direction of the EMR's propagation is perpendicular to the direction of the changing magnetic field and is also perpendicular to the direction of the changing electric field.
- All types of EMR travel at the speed of light (3.00×10^8 m/s in a vacuum).
- The seven colours of the visible spectrum may be remembered using the acronym ROY G BIV.

700 nm	400 nm
low energy	high energy
low frequency	high frequency
long wavelength	short wavelength

EMR may be considered to be a wave or a particle.

- EMR whose frequency is less than visible is generally more wave-like.
- EMR whose frequency is greater than visible is generally more particle-like.
- Visible light may be treated as both as a wave and a particle depending on the experiment or phenomenon.

21. The main areas of the electromagnetic spectrum are shown below. Classify the different regions as ionizing radiation, acts like a wave, or acts like a particle. Fill in the blanks.



Measuring the speed of light typically requires measuring large distances and/or short times.

Wave Mathematics

$$c = \lambda f$$

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

Tips

- Memorize the different sections of the EMR spectrum and their trends.
- The universal wave equation works for all types of EMR.

Speed of EMR

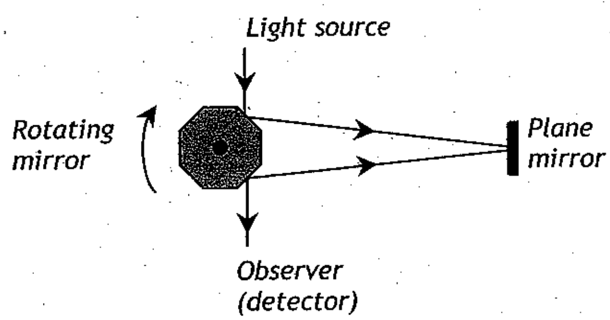
- All EMR travels at 3.00×10^8 m/s through a vacuum.
- Many experiments have been done to better measure this value.

22. An experiment using a spinning wheel with 360 cogs and a distance of 450 m between the wheel and the mirror was used to measured the speed of light to be 3.00×10^8 m/s. Determine the time required for light to travel from the spinning wheel to the mirror and back.

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

$$t = \frac{450 \times 2}{3.00 \times 10^8 \text{ m/s}} = 3.00 \times 10^{-6} \text{ s}$$

A rotating disk or mirror can be used to determine the speed of light. Michelson used the following apparatus to determine the speed of light.



The formula v = 2dnf works for many situations, though you should be able to derive it.

* I didn't use this formula; in class we learned to:

① use ratio to find time for $\frac{1}{8}$ R

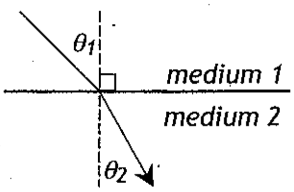
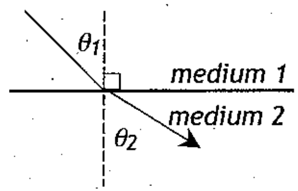
② since light makes round trip in the same time

$$v = \frac{2d}{t\left(\text{for } \frac{1}{8}\right)}$$

Refraction

Major points

Refraction is the changing of direction or bending of a ray as it passes from one medium to another. It is caused by a sudden change in speed as the waves pass from one medium to another.

Speed decrease	Speed increase
• The wave is faster in medium 1. • The refractive index of 1 is less than in 2.	• The wave is slower in 1. • The refractive index of 1 is greater than in 2.
	

Snell's Law

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$$

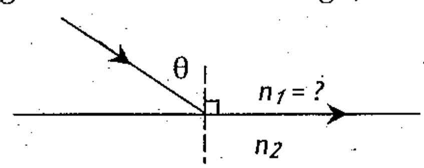
23. A ray of light from air strikes the surface of a block of glass, having a refractive index of 1.50, at an angle of 67°. Determine the angle of refraction.

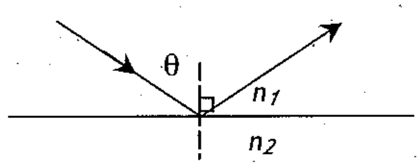
$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1} \qquad \frac{\sin 67}{\sin\theta_2} = \frac{1.50}{1.00}$$

$$\theta_2 = 38°$$

Dispersion is the separation of EMR into individual wavelengths. It occurs when waves pass from one medium to another.

When EMR travels from high to low refractive index it bends away from the normal line. If the incident ray is greater than the critical angle, total internal reflection occurs — the boundary acts as a mirror.





Total internal reflection may occur when EMR travels from a substance to another substance with a lower refractive index.

Tips

- For critical-angle questions the angle used for the angle of refraction is 90°.
- Draw a labelled diagram when solving refraction questions.

Lenses & Mirrors

Lenses and mirrors may be used to redirect the path of EMR and form images.

Major points

- The amount of redirection for a mirror depends only on its shape. For a lens, both its shape and refractive index will affect the amount light is redirected.

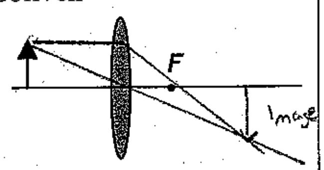
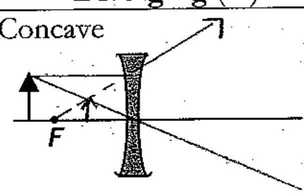
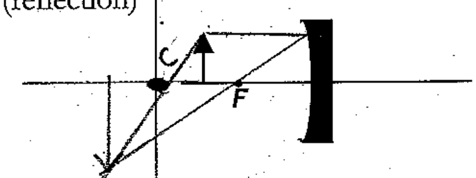
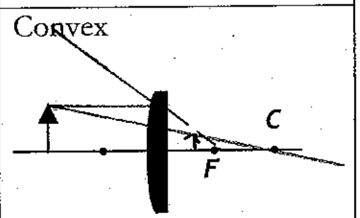
- The characteristics of an image include:
  Attitude: inverted or upright
  Type: real or virtual
  Size: larger or smaller than the object

Characteristics of an image may be determined using formulae or ray diagrams.

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

24. Lenses and mirrors can redirect light's path. Sketch a simple ray diagram for each situation below.

	Converging (+f)	**Diverging** (–f)
Lens (refraction)	Convex 	Concave 
Mirror (reflection)	Concave 	Convex 

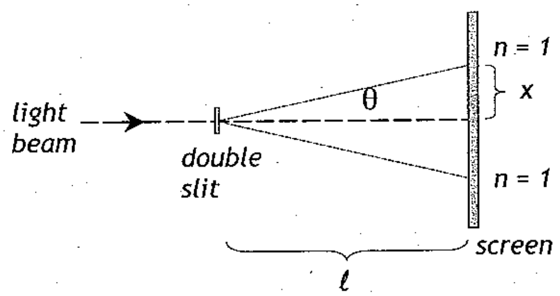
Tips

- It is very easy to mix up lenses and mirrors. Underline the word mirror or lens in a question to help make sure you do not solve for a mirror when the question asks for a lens and vise versa.
- The most efficient way to determine the characteristics of an image may be to draw a careful sketch.

Diffraction

Major points

- **Diffraction** is the spreading out of a wave as it passes a corner or through an opening. Since light diffracts, this is evidence that light must be a wave, not a particle.



$$\lambda = \frac{dx}{\ell n} \qquad \lambda = \frac{d\sin\theta}{n}$$

Tips

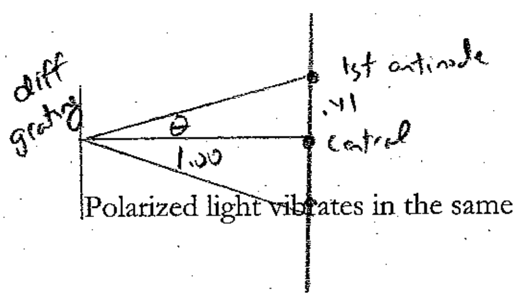
- The angle must be less than 10° for the first equation to give good results. If you are not given the angle, you should check using $\tan\theta = x/\ell$
- Blue light is affected more (deviates more — larger angle) by refraction while red is more affected more (deviates more — larger angle) by diffraction.

25. Monochromatic light falls on a pair of slits 1.35 μm apart. The maxima are measured to be 41.0 cm apart and the screen is a distance of 1.00 m from the slits. Determine the wavelength of the light. (Hint: Check the angle.)

$\lambda = \frac{d \sin\theta}{n} = \frac{(1.35\times10^{-6})(\sin 22.29)}{1} = 5.12\times10^{-7}$ m

$\lambda = \frac{dx}{n\ell} = \frac{(1.35\times10^{-6})(.41)}{(1)(1.00)} = 5.54\times10^{-7}$ m

small angle approx. make this answer wrong.



$\tan\theta = \frac{x}{\ell} = \frac{.41}{1.00}$

$\theta = 22.29°$

- Polarized light vibrates in the same plane. Polarization is evidence that light is a transverse wave.

Particle Nature of EMR

Major points

For certain behaviours, EMR must be thought of as a particle (photon).

- The Photoelectric Effect
- Compton Effect

EMR can act as a wave or a particle depending on the circumstance, even though they should be mutually exclusive (i.e., has to be one or the other; cannot be both).

The energy of a single photon is given by:

$$E = hf \qquad E = \frac{hc}{\lambda}$$

Tips

Slightly different answers may be obtained depending on the version of Planck's constant used.

26. A beam of monochromatic light having a wavelength of 560 nm is incident on a detector. The beam delivers 1.28×10^{-16} J of energy to the detector each second. Determine the number of photons incident on the detector in 2.00 seconds.

1) find total $E = Pt$

$= \frac{1.28 \times 10^{-16}\ J}{s} \times 2\ s$

$= 2.56 \times 10^{-16}\ J$

2) find E of a single photon

$E_{photon} = \frac{hc}{\lambda} = \frac{hc}{560 \times 10^{-9}} = 3.55 \times 10^{-19}\ \frac{J}{photon}$

3) $\frac{E}{E_{photon}}$ $\frac{2.56 \times 10^{-16}\ J}{3.55 \times 10^{-19}\ \frac{J}{photon}}$

$= 721$ photons in 2 secs.

The Photoelectric Effect

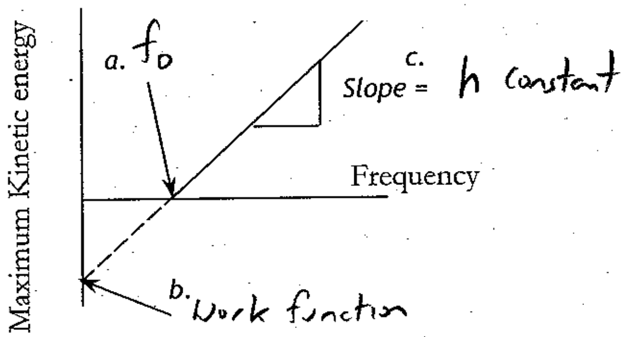
Major points

- Einstein explained the photoelectric effect using the premise that light must be a particle (photon), not a wave.
- Threshold frequency is the minimum frequency needed to release electrons from the metal's surface.
- Work function and threshold frequency are unique for every metal and can be used to identify a metal.
- The **law of conservation of energy** is used for photoelectric effect calculations:

  Photon energy = kinetic energy of electron + work function

27. Label the three main sections of the following photoelectric effect graph.

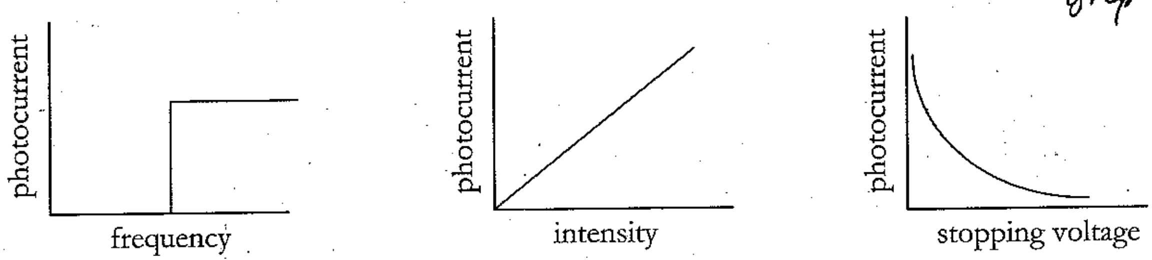
<u>Maximum kinetic energy as a function of frequency</u>



Kinetic energy in electron volts (eV) is numerically equal to the stopping voltage (e.g., if E_k = 10 eV the V_{stop} = 10 V).

More photoelectric effect graphs

* know pe graph shapes



Tips

- Light intensity is proportional to the number of photons present.
- Light frequency is proportional to a photon's energy.
- A photoelecton is identical to an electron.

The Compton Effect

Major points

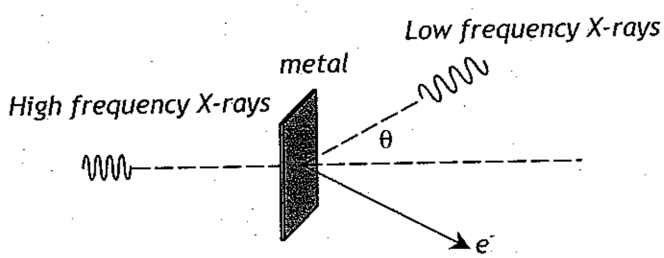
- The Compton Effect is explained based on light being a mass-less particle that has momentum.

$$p = \frac{h}{\lambda}$$

$$E = pc$$

- High energy EMR (e.g., X-ray or gamma ray) contacts an electron in an atom. The electron is ejected along with a lower energy X-ray.
- It provides evidence that light must be a particle (photon) not a wave.

Compton Equation



$$\Delta\lambda = \frac{h}{mc}(1 - \cos\theta)$$

Tips

- Use the J•s version of Planck's constant for Compton calculations. (6.63×10^{-34} J•s)
- Make sure you can solve a 2-D glancing collision between a stationary electron and X-rays.

28. Make a list of phenomena that suggest EMR must be a wave and a list of phenomena that suggest it must be a particle.

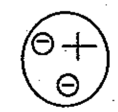
Wave	Particle
diffraction and interference } Young's double slit expt	pe effect
polarization (transverse waves)	Compton effect

Models of the Atom

Major points

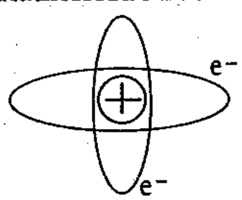
Here are four atomic models you must know:

Thomson's raisin bun model



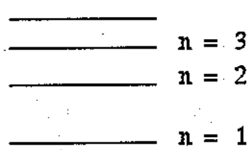
Thomson used cathode rays to discover the electron and determined its charge-to-mass ratio.

Rutherford's nuclear model



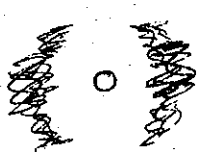
Rutherford used the scattering of alpha particles through a gold foil to find that an atom is mostly empty space surrounding a positive nucleus.

Bohr's energy level model



Evidence that the electrons can only be found in certain energy levels can be provided from absorption and emission spectra. Thus, the atom is quantized. The law of conservation of energy can be used to help solve these problems.

Wave mechanical model

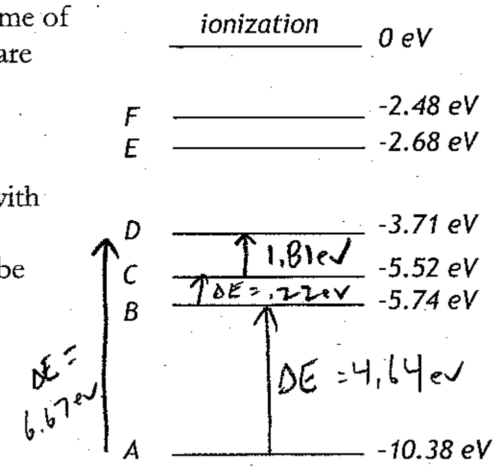


de-Broglie and others used the idea that the electron is a wave surrounding a nucleus to develop the wave mechanical model.

Tips

- Use the law of conservation of energy for energy level diagram questions.
- Cathode rays are composed of electrons emitted from the cathode of a CRT.
- Absorption spectrums occur when an electron goes up on an energy diagram. Emission spectra are produced when electrons go down on an energy diagram.

29. Mercury gas is used in compact fluorescent light bulbs. Some of the possible transitions for an electron in a mercury atom are given in the energy level diagram shown on the right.

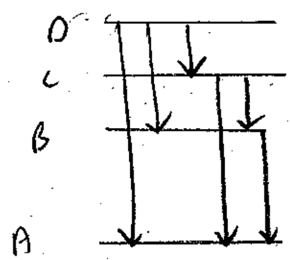


A passing electron that has a kinetic energy of 6.90 eV collides with the electron in a mercury atom at ground state. Determine the:

a. total number of different photons that could possibly be produced.

b. wavelength of the photon with the maximum energy.

- the passing electron will transfer 6.67eV of energy to the mercury e⁻ and retain 0.23 eV
- the Hg e⁻ will be excited to level D



a) this could result in 6 different photons produced

b) The photon with the max energy is from the electron with the greatest transition (D → A)

$$E = \frac{hc}{\lambda}$$

$$6.67\ eV = \frac{4.14\times10^{-15} \cdot 3.00\times10^{8}}{\lambda}$$

$$\lambda = 1.86\times10^{-7}\ m$$

186nm

Nuclear Physics

Major points

Radiation Safety

The danger of a radioactive substance is related to the:

- type of radiation produced.
- activity of the substance. Activity is the amount of radiation produced in a given time. It is dependent on the stability and the amount of the radioactive substance.

Safety can be improved when working with radioactive material by:

- decreasing exposure time.
- increasing distance between people and the radioactive material.
- increasing shielding used.

Four conservation laws are used in this unit:

- momentum
- charge
- nucleons
- mass-energy

Nuclear notation

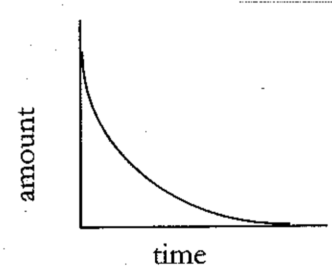
$^{A}_{Z}X$

Where:
X is the symbol of the element;
A is the atomic mass number (total number of protons and neutrons); and
Z is the atomic number (number of protons).

Types of nuclear radiation.

alpha	α^{2+}	helium nucleus (2 protons and two neutrons)
beta-negative	β^{-}	High-speed electrons from a nuclear source
beta-positive	β^{+}	
gamma	γ	High-energy EMR from a nuclear source

- Beta-negative decay occurs when a neutron changes into a proton and an antineutrino.
- Beta-positive (positron) decay occurs when a proton changes into a neutron and a neutrino.
- Balancing nuclear reactions depends on two conservation laws: **conservation of nucleons** and **conservation of charge**.
- **Mass-energy** is conserved in a nuclear reaction.
- Energy is released in a nuclear reaction because the total amount of matter decreases according to $E = mc^2$.
- All radioactive decays show a characteristic decay curve:



Fission occurs when a large nucleus is split into two daughter nuclei.

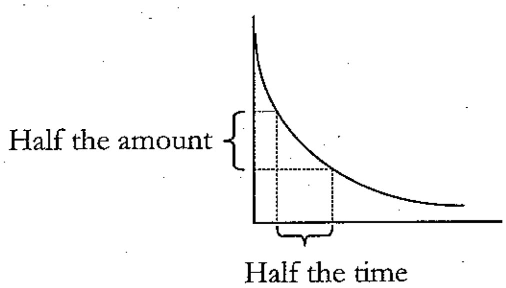
Fusion is the combining of small atomic nuclei to make a heavier element.

Half-life

$$N = N_0\left(\frac{1}{2}\right)^n$$

Where:

N is the amount remaining;
N_0 is the amount at the start; and
n is the number of half-lives.



Half-life can be found from the curve by selecting an amount then half that amount.

Tips

- The law of conservation of nucleons and the law of conservation of charge are used to balance and predict nuclear reactions.
- A moving electron is considered beta radiation when it is produced through a nuclear process.
- When asked to calculate a time or half-life, construct a table of n and amount: The log function on your calculator may also be used, if you are familiar with it.

n	amt.
0	1680
1	840
2	420 ←
3	210

Particle Tracks

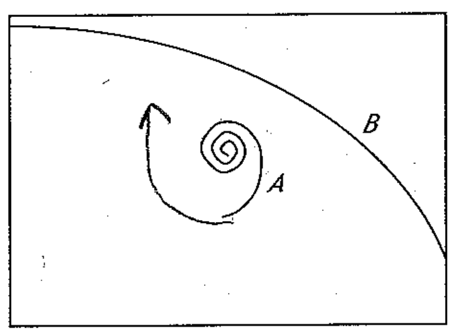
Detection chambers, such as bubble chambers, have been used to detect and analyze the nature of moving particles.

Photographs of the tracks can be analyzed knowing that:

- positive and negative particles curve in opposite directions.
- lighter particles tend to curve more than heavier particles.
- all conservation laws (e.g., momentum, charge) must be obeyed.
- neutral particles don't leave tracks.

30. An electron and a proton produce the tracks shown in the bubble chamber picture on the right.
    a. Identify the track most likely produced by the:
        i. electron.
        ii. proton.
    b. Determine the direction of the magnetic field.

Particles enter from here:



A - is the electron's track, B is the proton's track. Small particles will tend to curve more than larger particles

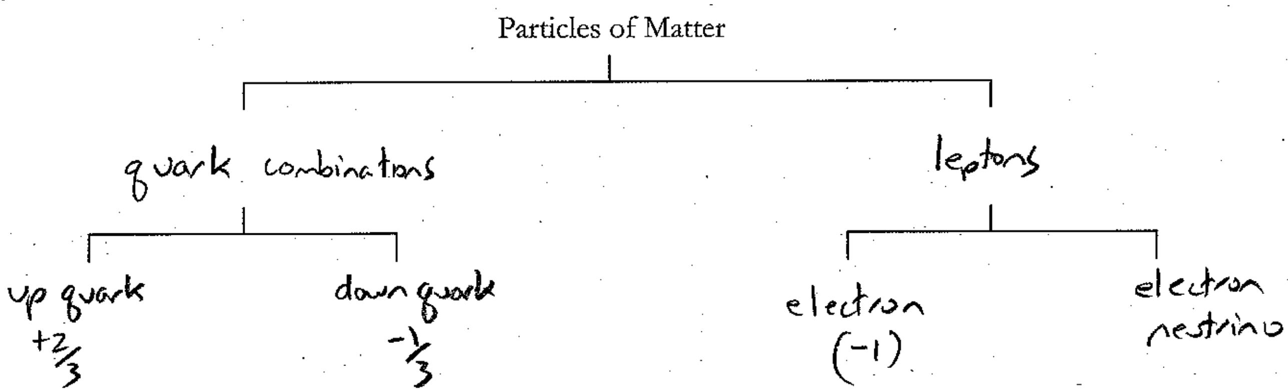
B - using 3rd hand rule $\vec{B}$ is ⊙

Standard Model

Major points

- The Standard Model attempts to organize the hundreds of subatomic particles.
- Quarks are fundamental particles that have fractional charges.
- Protons and neutrons are made from quarks.
- Electrons are elementary particles and therefore are not made from quarks or anything else.

31. Complete the following flow chart showing the relationship between first generation particles of matter.



Each particle has an associated antiparticle having opposite charge.

Tips

Your data table has quark charges so there is no need to memorize them.

32. Quarks that make up normal matter must be first generation quarks (no antiquarks are allowed, since combinations of matter and antimatter are unstable). Use the charge on quarks to identify the three quarks that make up a:

a. Proton.

$u + u + d$

$\frac{2}{3} + \frac{2}{3} + \frac{-1}{3} = +1$

b. neutron.

$u + d + d$

$\frac{2}{3} + \frac{-1}{3} + \frac{-1}{3} = \emptyset$

Strategies for the Physics 30 Diploma Exam

Multiple Choice Strategies

The multiple choice responses have a nearly equal amount of As, Bs, Cs and Ds. They make sure no pattern appears; guessing is a 25 % proposition.

If you have spent two minutes and still do not have an answer, go on to the next question and come back to it later.

Show all your work because:

- there is less chance of making mistakes.
- it is easier to check your work.

Scenario questions may give extensive context or background preceding a series of questions. Much of the context is not required to solve the associated questions. Some students find it advantageous to try the questions before reading the context.

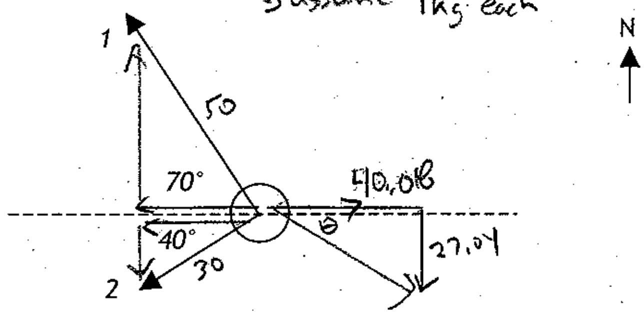
33. A 250 g ball is travelling at 12.0 m/s to the north when it is hit by a bat and moves at 14.0 m/s to the south. The impulse of the ball is:
    A. 0.50 kg•m/s, north.
    B. 0.50 kg•m/s, south.
    C. 6.5 kg•m/s, north.
    D. 6.5 kg•m/s, south.

$$\text{Impulse} = \Delta p = m\Delta v = m(v_f - v_i) = .250(-14.0 - 12.0) = .250(-26.0) = -6.5 \text{ kg}\cdot\text{m/s or } 6.5\ [S]$$

Use the following information to answer the next question.

A toy contains a wound-up spring. A timer releases the spring, causing the toy to explode into three identical pieces that move along the floor. Two of the pieces travel as shown below. Piece number 1 travels at 50 cm/s while piece number 2 travels at 30 cm/s.

↳ assume 1kg each



34. The direction the third piece moves is:
    - (A) 35° S of E.
    - B. 35° N of E.
    - C. 55° N of E.
    - D. 55° S of W.

X	Y
$0 = -(\cos 70 \times 50) + -(\cos 40 \times 30) + p_{3x}$	$0 = (\sin 70 \times 50) + -(\sin 40 \times 30) + p_{3y}$
$0 = -17.10 + -22.98 + p_{3x}$	$0 = 46.98 + -19.28 + p_{3y}$
$40.08 = p_{3x}$	$0 = 27.704 + p_{3y}$
	$-27.04 = p_{3y}$

$\tan\theta = \frac{27.04}{40.08} = 34°$ SE

or you could do this more quickly with a scale diagram.

35. Two charges, –6.0 μC and +4.0 μC, are separated by a distance of 60 cm. The electrostatic attractive force between them is:
    - A. 6.0×10^{-5} N
    - B. 3.6×10^{-3} N
    - (C) 0.60 N
    - D. 0.36 N

Coulomb's Law

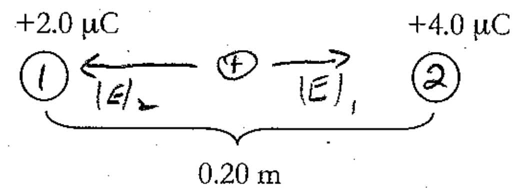
$F_{el} = \frac{k q_1 q_2}{R^2}$

$= \frac{k(6.0\times10^{-6})(4.0\times10^{-6})}{(0.60)^2}$

$= 0.5993$ N

Use the following information to answer the next question.

Two charges are separated by a distance of 0.20 m as shown in the diagram below.



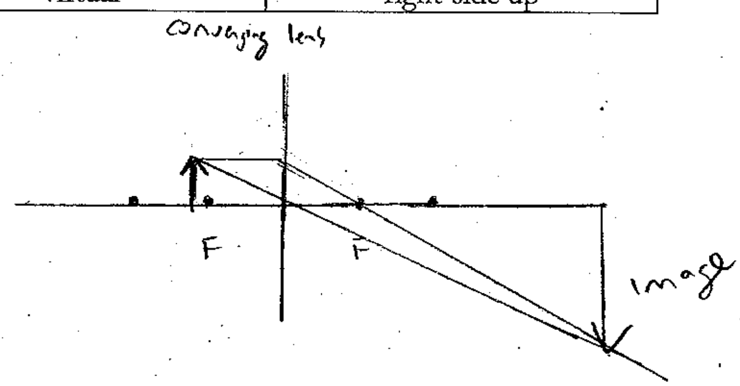
$|E| \propto q$

36. Determine the magnitude of the electric field at the midpoint between the two charges.
   - A. 1.8×10^6 N/C
   - B. 1.8×10^5 N/C
   - C. 1.8 N/C
   - D. 5.4×10^6 N/C

$$|E|_{net} = |E|_2 - |E|_1 = \frac{k\,4\times10^{-6}}{(.1)^2} - \frac{k\,2\times10^{-6}}{(.1)^2} = 1.8\times10^6\ \text{N/C}$$

37. A candle is placed 5.0 cm away from a convex lens having a focal length of 4.0 cm. The image type must be ___**i**___ and the orientation of the image is ___**ii**___.

	i) Image type	ii) Orientation
A.	real	upside down
B.	real	right-side up
C.	virtual	upside down
D.	virtual	right-side up



real
inverted
larger

Numerical Response Strategies

Three types of numerical response questions will be on the diploma exam.

- answer from a calculation
- selecting from a list or a diagram
- identification of a sequence of events

The numbers must be correctly entered into the box. The front of the exam has examples.
Show your work.

- Record your answer on the answer sheet provided by writing it in the boxes and then marking the corresponding circles.
- For an answer between 0 and 1 (e.g., 0.35), record the 0 before the decimal place.
- Enter the first digit of your answer in the left-hand box and leave any unused boxes blank on the right.

38. A 1.21 cm long current-carrying wire is suspended in a magnetic field. The wire's mass is 2.21 g and the current passing through it is 4.51 A. The magnetic field strength, expressed in scientific notation is ______ $\times 10^{-w}$ T.

(Record your **three-digit** answer in the numerical-response section on the answer sheet.)

suspended - forces balanced

$\uparrow F_m$

$\downarrow F_g$

$F_m = F_g$

$B I l = mg$

$B_\perp \, 4.51 \cdot 1.21 \times 10^{-2} = 2.21 \times 10^{-3} \cdot 9.81$

$B_\perp = 0.397\ldots$ T

3.97

3.97×10^{-1}

39. A beam of photons is produced from a laser to give a total energy of 4.27×10^{-13} J/s. Each photon has an energy of 5.25×10^{-16} J. The number of photons emitted by the laser in 2.00 s expressed in scientific notation, should be a.bc $\times 10^{d}$. The values of a, b, c, and d are ______, ______, ______, ______. (Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

1633

$E = Pt$

$= 4.27 \times 10^{-13} \frac{J}{s} \cdot 2 s$

$= 8.54 \times 10^{-13}$ J

$E_{photon} = 5.25 \times 10^{-16} \frac{J}{photon}$

$\frac{E}{E_{photon}} = \frac{8.54 \times 10^{-13} J}{5.25 \times 10^{-16} \frac{J}{photon}}$

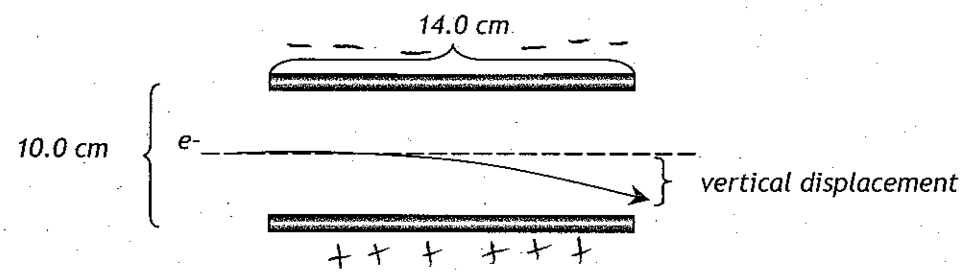
$= 1626.6$

1.63×10^{3} photons

Two NR questions will be linked to the same scenario. One of the questions will ask you to identify the two physics principles necessary to solve the question. The second NR will require the answer to the calculation. This NR question may be a challenging calculation. You may want to leave it to the end.

Use the following information to answer the next two questions.

An electron moving horizontally at 2.50×10^6 m/s enters a 150 N/C electric field exactly halfway between two horizontal parallel plates and follows a parabolic path as shown in the diagram.



Use the additional information below to answer the next question.

Six out of the 10 Physics principles from your data sheet are listed below. Use these six principles to answer question 40.

1. Uniform motion (balanced forces) → horizontal motion
2. Uniformly accelerated motion (unbalanced forces) → vertical motion
3. Work-energy theorem
4. Conservation of momentum
5. Conservation of energy
6. Conservation of charge