# SPH3U Grade 11 Physics Exam

SPH3U Grade 11 University Physics Final Exam Study Notes/Guide

**Waves unit study notes soon to follow**

Forces

Force
- acceleration requires force
- push or pull
- measured in Newtons (N)
- causes objects to accelerate or decelerate
- objects accelerate when there is a net force acting on it
- objects moving at constant speeds do not have net force
- objects at rest do not have net force

Fundamental Forces
- 4 Fundamental forces
- Gravitational force
- Electromagnetic force – electrons/protons attract/repel
- Weak nuclear force
- Strong nuclear force – holds nucleus of atoms together
- Other everyday forces are one or more of these acting in a specific way

Everyday Forces
- Force of friction – always parallel to a surface, resisting motion
- Magnetic force
- Electrostatic force
- Normal force – stops things from going through a surface, acts perpendicular to a surface
- Force of buoyancy – causes less dense objects to float in denser liquids
- Force of tension
- Force of gravity
- Applied force
- Majority of the forces discussed in this unit are contact forces, meaning the force is a result of two objects making contact with one another

Free-Body Diagrams (FBD)
- diagram of forces acting on an object
- Steps: 1) draw a diagram of the object isolated from surroundings

2) draw all forces acting on the object with arrows

3) forces are usually all draw through the same point in the object

Newton's First Law of Motion
- If net force on an object is 0, the object will either stay at rest or constant velocity

Δ d is change in displacement/change in distance
Δ t is change in time
$\mu K$ is the co-efficient for friction for moving objects
$\mu S$ is the co-efficient for friction for stationary objects
FfK is the force of friction of moving objects
FfS is the force of friction of stationary objects
G = 6.67 x 10-11

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FNET = m x a
Fg = (G x mass1 x mass2) / d2
Fg = m x 9.8 – only for objects near or on Earth's surface
FfK = $\mu K$ x FN
FfS = $\mu S$ x FN
a = ΔV / Δt
Vav = Δd / Δt
Δd = Vi Δt + ½ a Δt2
Δd = Vav Δt
Vf2 = Vi2 + 2aav Δd
Δd = Vf Δt – ½ a Δt2

Energy

Topics
Energy/Work – Eg, EK, W, EM, conservation of energy, efficiency, power
Heat/Thermal Energy
- methods of heat transfer – conduction, convection, radiation
- heat problems
- latent heat
- equilibrium
Need-to-know Terms
- heat capacity
- latent heat
- power
- energy

Energy/Work
Work (W)
- energy transfer
- done when a force is applied as an object is moved a certain distance
- SI units for work is Joules (J)
- Increases/lowers energy of an object by transferring energy
- Work = Force X Distance
- W = (F)(Δd)
- Distance is always measured along the same line as the force that is being applied

Gravitational Potential Energy (Eg)
- potential energy is energy stored in an object
- potential energy can be released
- gravitational potential energy is the energy that can be released by an object falling from a particular height
- Eg = W = (Fg )(height)
- Therefore, Eg = (m)(9.8)(h)
- E.g. A ball weighing 2 kg is dropped from 50 m above the ground, what is its gravitational potential energy?
- Eg = (2)(9.8)(50)

- Eg = 980 J

Kinetic Energy (EK)
- energy an object possesses as a result of its motion
- objects travelling at higher velocities have more energy
- more net force for a particular distance will result in higher velocity due to acceleration, meaning more kinetic energy
- Ek = W = (m)(a)(Δd)
- The above equation can be re-arranged to create: EK = (m)(V)2 / 2

Efficiency
- cars are incredibly inefficient machines
- all energy transformations result in some sort of energy lost to heat
- efficiency of a device is the ratio of useful energy output to energy input (expressed as percentage)
- Efficiency = (useful energy output / energy input)(100)
- Efficiency = (EOUT / EIN)(100)

Mechanical Energy (EM)
- simply the Eg + EK of an object

Conservation of Energy
- energy never just disappears
- energy is always transforming into different forms
- e.g. a ball that is rolling slows to a stop because the kinetic energy is possessed was being transformed into heat energy due to friction

Power (P)
- defined as the rate of change of doing work
- it is the energy that is transferred, produced or used in a certain amount of time
- power = work / time
- P = ΔE / Δt
- SI unit is the Watt (W), named after James Watt who invented the modern steam engine
- 1W = 1J / 1s
- Horsepower is a non-metric unit sometimes used to measure power
- 1 hp = 746 W

Heat/Thermal Energy
- thermal energy is the total kinetic energy and potential energy of the molecules or atoms within a substance measured in Joules (J)
- temperature is the measure of the average kinetic energy of the molecules or atoms within a substance
- temperature is measured in degrees Celsius or Kelvin
- 0K = -273.16 degrees Celsius

Equilibrium
- two objects reaching the same temperature together
- involves the heat capacity, mass, and initial temperature of the objects

Heat Transfer
- symbol for heat is Q and units for heat are Joules (J)
- heat is similar to work
- can be transferred via conduction, convection, and radiation

Conduction
- transfer of energy between molecules of one or more solids
- occurs because of collisions between molecules

Convection
- as a fluid (gas/liquid) becomes warm, the molecules become less dense and rise
- molecules carry thermal energy, resulting in heat transfer
- as fluid cools down, it begins to fall, creating a circular current
- advection is hot fluids moving sideways rather than upwards

Radiation
- transfer of energy through electromagnetic waves like light, x-rays, ultraviolet radiation, infrared radiation, etc.
- radiation can travel through space and does not require molecules
- as radiation comes in contact with an object, it may or may not increase the object's thermal energy
- certain frequencies of microwaves can cause water to heat up significantly but have little to no effect on ceramic

Infrared Radiation
- infrared radiation is a part of the electromagnetic spectrum
- invisible to human eye
- molecules release thermal radiation over time
- thermographs can create a picture of an object from the release of its infrared radiation

Calculating Heat
- energy lost or gained by an object is proportional to mass and change in temperature of the substance
- m is mass in kg, Q is heat, $\Delta T$ is the change in temperature = T2 – T1
- c is a constant that's called the specific heat capacity
- $Q = (m)(c)(\Delta T)$

Latent Heat
- phase changes occurs when a substance changes state
- solid to liquid (melting)
- liquid to solid (freezing)
- liquid to gas (evaporation
- gas to liquid (condensation)
- solid to gas (sublimation)
- gas to solid (deposition)
- during phase change, the temperature of the object does not change
- the energy during a phase change goes towards breaking the bonds of molecules
- energy is added/removed from substances
- added energy works on bonds that keeps the substance in its current state
- energy given off is the energy that was used to keep it in its current state
- different substances require different amounts of energy
- energy added/given off during phase change is called latent heat
- latent heat fusion (Lf): energy that is required to turn a liquid to solid or given off when solid turns to liquid
- $Q = (m)(Lf)$
- latent heat of vaporization (LV): energy that is required to turn a liquid into gas or given off when gas turns to liquid
- $Q = (m)(LV)$

Energy Resources
- energy source – raw material that can be used to create work (e.g. fuels, solar power, etc.)
- renewable – regenerates in a human lifetime

Active Solar
- process of absorbing the sun's energy and converting it into other forms of energy, such as electricity
- radiant energy from the sun
- produces small amounts of electrical energy
- renewable source of energy
- expensive to set up
- only available when the sun is out

Passive Solar
- process of designing and building a structure to take best advantage of the sun's energy at all times of the year
- renewable
- expensive to set up
- only available when sun is out

Hydraulic
- energy produced by extracting potential energy from the water – gains potential energy from gravity, due to precipitation
- renewable
- only available where water flows regularly

Wind
- energy produced by utilizing the kinetic energy of wind
- readily available where wind is
- does not create pollution
- only available where wind is
- available throughout Canada and across the world
- not practical to install a wind turbine for a single home
- usually costs more to get wind energy from suppliers
- wind turbines are very loud and large
- compared to other energy plants, wind energy plants tend to be easier to set up

Tidal
- available where ocean tides are large
- results from moon and sun
- dams harness the energy of the moving water
- doors are opened and closed to exploit the most energy out of the water
- no air/thermal production
- hard to produce electricity at certain times
- dams effect ecology

Biomass
- chemical potential energy in plant and animal waste
- indirect result of sun, burning wood is an example
- can be harnessed from many different sources
- if not used correctly, could not be renewable

Geothermal
- energy taken from underneath Earth's surface
- results from radioactive decay, the nuclear fission of elements in rocks
- heated water gathers energy from below Earth's crust
- renewable but hard to harness

Nuclear Fusion
- nuclei of atoms of light elements join together at high temperatures to create larger nuclei

- as mass is lost, energy is created
- resulted from sun and stars
- limitless supply of fuel and less radioactive waste than nuclear fission
- needs heat and confinement to work

Electromagnetism

Topics
• Electric fields
• Calculating electric properties
• Solving a circuit
• Charging objects
• Types of magnets
• Drawing magnetic fields
• Domain theory
• Key Terms
• Electromagnets & right hand rules
• Circuits with solenoids (electric bell)
• Motors
• Electromagnetic induction
• Lenz' law
• Transformers
• Magnetic storage
• CRT

Electric Fields
- forces are visualized using the field theory
- field of force exists in a region of space when an object placed at any point in the field experiences a force
- forces occur between objects
- defined as: force per unit positive charge
- vector quantity
- $\epsilon = Fe / q$ – electric field is equal to electric force over charge
- measured in Newtons/Coulomb
- field strength gets stronger with shorter distances
- fields can be represented with lines that indicate direction of force
- field lines never cross
- similarly, gravitational field is defined as the gravitational force per unit mass
- field strength = Kq/d2

Calculating Electric Properties
- current is defined as the amount of charge that passes a point each second
- I is the symbol for current
- Current can either be direct of alternating
- Direct current (DC): current flows in only one direction, created by batteries
- Alternating current (AC): current alternates direction, created by generators
- Amperes (A) are the units for current
- Current = charge over time
- $I = Q/t$
- Resistance depends on material, length of wire, and the cross-section of the wire
- R is the symbol and ohms are the units
- Electrical potential difference is the voltage of the circuit
- Symbol is V and units are volts (V)
- More potential difference increases the amount of current
- $V = I \times R$

Circuits
- Electron flow is opposite to current
- Short circuits occur when there is little to no resistance and high current
- current is the same at every point in a closed loop (in series)
- current splits up at a branch/junction
- the total current of each branch adds up to the current entering the branch
- potential difference adds up in series
- potential difference is equal in parallel
- resistance adds up in series
- Resistors in parallel use this equation: 1/Requivalent = 1/R1 + 1/R2 + etc...
- Voltage law: sum of the increases in electrical potential = sum of decreases in electrical potential
- Current law: total electrical current before a junction = total electrical current out of the junction

Charging Objects
- induction: when the charge of an object changes when a different charged object is brought near
- conduction: when electrons are actually passed on from an object

Types of Magnets
- magnets have poles (N and S)
- opposite poles attract and similar poles repel
- natural magnets are often found on earth in mines
- e.g. lodestone, magnetite
- artificial magnets are made by mining various metals
- they can be very strong and are used in many products
- ferromagnets become magnets when brought close to other magnets
- they become magnetized for a period of tie, and are mostly steels or irons

Domain Theory
- the smallest part of a magnet is called a dipole
- a group of these dipoles is called a domain
- no such thing as a mono-pole – there has to be a N and a S not either or
- in magnets the dipoles all point in one direction
- in ferromagnets are aligned randomly
- when a ferromagnet is magnetized, the dipoles line up and act like a magnet
- magnetic field lines point away from North towards South

Key Terms (Pg 447)
- demagnetization: when aligned dipoles return to random directions, for soft ferromagnetic materials, they demagnetize when removed from the magnetic field
- reverse magnetization: occurs when magnets are placed in strong enough magnetic fields and the poles go in the opposite directions
- breaking a bar magnet: produces new pieces with dipole alignments similar to the original
- magnetic saturation: when the max number of dipoles of an object are aligned
- induced magnetism by earth: iron in earth's magnetic field will have their dipoles aligned while heated or vibrated
- keepers for bar magnets: bar magnets become demagnetized over time due to the reverse of polarity – by storing in pairs with small pieces of iron (keepers), this can be prevented

Right Hand Rules
- Right hand rule #1: with straight wires, thumb points in direction of current and the curl of the fingers indicates magnetic field

- Right hand rule #2: with solenoids, wrap fingers in the direction of the current and the thumb points to N
- Right hand rule #3: with motors, use an open hand – fingers point in direction of magnetic field, the thumb points in the direction of current (I), and the force is away from the palm

Solenoids
- when wrapping wire, the field goes through the centre of the coiled wire – coiled wire pretty much turns into a bar magnet
- this wire is called solenoid
- solenoids allow for controlled magnets
- strength of the solenoid depends on: current in coil, number of loops in coil, and type of core material
- relative magnetic permeability (K)
- K = magnetic field strength in material / magnetic field strength in a vacuum

Motors
- when a wire or coil carries current it creates a magnetic field
- if the field of the wire is near another magnetic field, the wire or coil can be made to move

Electro-Magnetic Induction
- a coil conducting current creates a magnetic field
- moving a wire through a magnetic field created electrical current
- law of electro-magnetic induction – an electric current is induced in a conductor whenever the magnetic field surrounding the conduction changes
- mutual induction – changing current in one coil produces a current in another coil (through induction) – mutual induction can be demonstrated with Faraday's iron ring

Lenz' Law
- current induced in a coil by a magnetic field is in such direction that the magnetic field that the coil creates opposes the changing field that originally induced the current

Transformers
- secondary coil with more windings creates higher voltage but less current
- transformers are modified versions of Faraday's ring – used to increase/decrease voltage of an AC source
- Equation: Voltage of the secondary coil / voltage of primary coil = # of windings of secondary coil / # of windings of primary coil
- $V_s / V_p = N_s / N_p$
- If you double the number of windings in the secondary coil, the voltage in the coil doubles
- In an ideal transformer, the power in both coils are equal
- Another equation: $V_p / V_s = I_s / I_p$ – V is voltage and I is current
- 2 types of transformers: step up and step down
- Step up creates a higher voltage in secondary coil while step down creates a lower voltage in secondary coil

Magnetic Storage and CRT
- refer to textbook readings to understand these two concepts

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- SPH3U Grade 11 Physics Electricity and Magnetism Test
- SPH3U Grade 11 Physics Energy and Heat Test
- SPH3U Grade 11 Physics Forces Test
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