AU SPECIAL SCHOOL

PHYSICS SUMMARY

GRADE 9

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UNIT 1 - VECTORS

- All physical quantities are either vectors or scalars.
- Vector quantities have both a magnitude and a direction.
- Vectors must include a direction.
- Arrows are used to represent vectors.
- The resultant is the sum of two or more vectors.
- When adding vectors their direction is very important.
- The parallelogram method is a quick and easy way to
- determine the resultant vector.
- To add perpendicular vectors mathematically you use Pythagoras's theorem to find the size of the resultant and trigonometry to determine its direction.
- Resolving a vector means splitting it into two components.
- Resolving vectors enables you to find the result for vectors at different angles.
- An object is said to be in equilibrium when there are no resultant forces acting on it.
- Scale diagrams can be used to determine whether or not an object is in equilibrium.
- If there are three forces acting on an object in equilibrium then when drawn they form a triangle.
- Using the component method, you can mathematically determine if an object is in equilibrium.

UNIT 2 – Motion in a straight line

- Uniform motion is when an object travels at constant speed in a straight line.
- Distance is a scalar quantity, whereas displacement is a vector quantity.
- Average speed = distance travelled / time taken.
- Average velocity = displacement / time taken.
- Instantaneous velocity is the velocity at any given instant in time.
- Acceleration is defined as the rate of change of velocity.

- Acceleration is measure in m/s2.
- When an object is uniformly accelerated, its acceleration remains constant.
- Distance–time, displacement–time and velocity–time graphs may be used to represent an object's motion.
- The gradient of a displacement–time graph is equal to the velocity of the object.
- The gradient of the line of a velocity–time graph is equal to the acceleration.
- The area under the line of a velocity–time graph is equal to the displacement.
- Acceleration is defined as the rate of change of velocity.
- Acceleration is measured in m/s2.
- There are five equations that describe uniformly accelerated motion; these can be used to solve a range of problems.
- The directions of the velocity and the acceleration of an object are important when deciding whether they are positive or negative values.
- When an object accelerates under gravity it is said to be in free fall.
- The equations of uniform acceleration can be used to solve problems relating to free fall.
- A frame of reference refers to a certain point of view depending on the position and motion of the observer.
- The laws of motion only apply if the reference frame of the observer is stationary or moving at a constant velocity.
- The velocity of an object depends on the frame of reference of the observer.
- The relative velocity between one moving object and another is given by the difference between their velocities.

UNIT 3 – Forces and Newton's Laws

- Forces can either be classed as contact or non-contact. Examples of forces include friction, drag, weight, gravitational attraction and contact forces.

- Newton's first law states: "An object will remain at rest or travelling at a constant velocity unless acted upon by an external force".
- Inertia is the tendency of an object to resist changes to its motion. The greater the mass of an object the greater its inertia.
- Hooke's law states: "The force applied to a spring is directly proportional to the extension of the spring up to the elastic limit".
- The stiffer the spring the greater the spring constant (k; measured in N/m).
- Elastic deformation means when forces are removed the object will return to its original length. Plastic deformation means when the forces are removed the object does not return to its original length; it is permanently stretched.
- The overall force acting on an object is called the resultant force. The equilibrant force is the force that needs to be applied to cancel out the resultant force.
- A resultant force will cause an object to accelerate in the same direction as the resultant force.
- Newton's second law states: "Force is directly proportional to acceleration, as long as the mass remains constant, and the acceleration is in the same direction of the force". This gives us $Fnet = ma$.
- In order to determine the resultant force, the forces acting on the object may need to be resolved then combined together again.
- Mass is a measure of the amount of matter measured in kg, whereas weight is a force measured in N caused by gravity pulling on an object's mass.
- Friction is a force generated when solids either attempt to slide or slide over each other.
- Friction is caused by bumps in the surface of the materials.
- Static friction occurs when objects try to move past each other. Kinetic friction occurs when objects slide over each other; it acts in the opposite direction to motion.
- Frictional forces can be calculated using $F = \mu N$ (where N is the normal contact force – this reduces if the object is on an inclined plane).
- Newton's third law states: "If body A exerts a force on body B then body B will exert an equal and opposite force on body A".

- Newton's third law means forces always come in pairs.
- Linear momentum is defined as the product of an object's mass and velocity (as given by $p = mv$). It is a vector quantity measured in kg m/s.
- The law of conservation of momentum states: "In a closed system the total linear momentum remains constant." This means if there are no external forces acting then the total momentum before a collision/explosion must be the same as the total momentum after the collision/explosion.
- The impulse of a force is defined as the force multiplied by the time the force is acting. It has units of N s. Impulse is equal to the change in momentum of an object.
- Collisions can be classed as elastic or inelastic.
- In an elastic collision the kinetic of energy of the system does not change.
- A system/object is in linear equilibrium if there is no resultant force acting on it.

UNIT 4 – Work, Energy and Power

- Work done is another way of saying energy transferred.
- Mechanical work is done whenever you move a force through a distance.
- The work done may be found using the equation: $W = F\ s\ cos\ \theta$
- Work done may be positive or negative depending on whether the object in question gains or loses energy.
- When an object does work, the work done is equal to the change in energy of the object. $W = \Delta E$. Or $W = -\Delta U$ if there is change in potential energy.
- Any moving object has a kinetic energy given by $Ek = ½mv2$.
- Potential energies are 'stored energies'. For example, GPE and EPE.
- GPE = mgh and EPE = $½F\Delta x$ (or $½k\Delta x2$).
- The total mechanical energy of an object is given by the sum of its kinetic and potential energies.

- The law of conservation of energy states that energy cannot be created or destroyed, just converted from one type to another.
- In elastic collisions both kinetic energy and linear momentum are conserved. In an inelastic collision only momentum is conserved.
- In oscillating systems (such as simple pendulum or mass– spring systems) potential energy is continuously transformed into kinetic energy and back again.
- A renewable energy resource is one that does not involve a fuel that will eventually run out.
- Wind, solar, geothermal and hydroelectric energy resources all offer significant benefits; however, they each have their drawbacks.
- Power is defined as the rate of doing work (power = work done / time taken).
- Power is measured in watts (or kW) and 1 W is 1 joule per second.
- The scientific unit of work/energy is the joule. However, other units are commonly used, including the kilowatt-hour (kWh).
- For a moving object, $P = Fv$.

UNIT 5 – Simple Machines

- A machine is a device that makes it easier to do mechanical work.
- There are six different types of simple machine: inclined plane, wedge, screw, lever, wheel and axle, and pulley.
- Machines can be classed as force multipliers/speed multipliers and/or direction changers.
- The force put into a machine is called the effort; this may be used to move a load.
- The work output from a machine is equal to the load × the distance moved by the load.
- The work input to a machine is equal to effort × distance moved by the effort.
- AMA = load /effort.
- VR = distance moved by effort / distance moved by load.
- η = MA/VR can be derived from efficiency = work output / work input and the equations for MA and VR above.

- If the machine is 100% efficient then VR = AMA = IMA.
- For an inclined plane the AMA = load /effort, where the load = the weight of the object and the effort = the force required to push the object up the slope ($mg\sin\theta$ + frictional forces).
- If we assume there is no friction on an inclined plane then VR = IMA = length of the slope (l) / height of the slope (h).
- For a wedge the AMA = load /effort, where the load = the force applied to the object being split apart and the effort = the force applied to top surface of the wedge.
- If we assume there is no friction on the wedge then VR = IMA = penetration length (L) / wedge thickness (t).
- For a lever the AMA = load / effort and the VR (and so IMA) = distance of the effort to the fulcrum (dE) / distance of the load from the fulcrum (dL).
- There are three orders of levers, depending on the relative positions of the load, fulcrum and effort.
- For a wheel and axle the AMA = load / effort and the VR (and so IMA) = radius of wheel (R) / radius of axle (r).
- There are three different types of pulley systems: fixed, movable and compound.
- For a pulley the AMA = load / effort and the VR (and so IMA) = the number (N) of sections of rope used to lift the load.
- A complex machine is a combination of two or more simple machines (for example, a jackscrew is a combination of screw and lever – this can be used to lift very heavy loads).
- Pressure is defined as the force acting per unit area. It can be calculated using the equation $p = F/A$.
- Pressure is measured in pascals (Pa), where 1 Pa equals a pressure of 1 newton per square metre.
- Atmospheric pressure is caused by the weight of the column of air above you pushing down on you. On a typical day this is equal to 101 kPa.
- As your altitude increases the atmospheric pressure decreases.

- A barometer is a simple instrument used to measure atmospheric pressure. The pressure from the atmosphere pushes the fluid up the tube.
- 1 atm is equal to 760 mmHg.

UNIT 6 – Fluid Statics

- A fluid is any substance that can flow. This includes gases as well as liquids.
- Gases may be compressed but liquids are incompressible.
- Density is defined as the mass per unit volume and it may be calculated using the equation $\rho = m / V$. Density is measured in kg/m3.
- The relative density of a substance is the density of the substance compared to another (e.g. compared to water).
- In fluids the pressure increases with depth and is the same in all directions.
- In fluids the pressure due to the fluid is equal to $p = h\rho g$. The total pressure is equal to the pressure due to the fluid plus atmospheric pressure.
- Pascal's principle states that liquids transfer pressure from one place to another without any reduction in pressure.
- Gauge pressure is the difference between absolute pressure and atmospheric pressure.
- A manometer is a simple U-shaped tube filled with liquid used to measure pressure.
- The apparent weight of a body is equal to the weight of the object minus the buoyant force acting on it.
- Archimedes's principle states that the weight of the displaced fluid is equal to the buoyant force acting on the object.
- The principle of flotation states if the buoyant force (or weight of displaced fluid) is equal to the weight of the object then the object will float.
- If the object is floating then the density of the floating object can be calculated from: $\rho_{object} V_{object} = \rho_{fluid} V_{fluid}$ where V_{fluid} is the volume of the displaced fluid.

UNIT 7 – Temperature and Heat

- Heat is energy transferred from hotter regions to cooler ones.
- The temperature of a substance is an indication of the average kinetic energy of the particles and the Celsius and Kelvin scales are both temperature scales.
- On heating, the particles of a substance move faster and move further apart so that a substance expands on heating.
- The first law of thermodynamics states that during heat transfer processes, energy cannot be created or destroyed.
- The second law of thermodynamics states that heat energy will flow from hot objects to colder objects and that if work is put in, heat energy can be removed from a cold object.
- When bodies are in thermal contact, heat energy flows from hot objects to cold objects until thermal equilibrium is reached and the bodies are at the same temperature.
- The thermal expansion of solids can be explained in terms of the increasing distance between particles that occurs on warming.
- The expression for the linear expansion of solids is $\Delta l = \alpha l c \Delta T$ – we can use this to find by how much the length of a sample expands.
- The expression for the surface area expansion of solids is $\Delta A = \beta A c \Delta T$ – we can use this to find by how much the surface area of a sample expands.
- The expression for the volume expansion of solids is $\Delta V = \gamma V c \Delta T$ – we can use this to find by how much the volume of a sample expands.
- The relationship between the coefficient of linear (α), area (β) and volume (γ) expansion is as follows: $\beta = 2\alpha$, $\gamma = 3\alpha$.
- The applications of thermal expansion include the bimetallic strip in thermostats, hot riveting and thermometers.
- The real expansion of a liquid is less than the apparent expansion as the vessel holding the liquid also expands.

- The abnormal expansion of water can be explained in terms of its more open molecular structure below 4 °C.
- Gases expand more than both solids and liquids for a given rise in temperature.
- The specific heat capacity of a substance is the heat energy required to raise the temperature of 1 kg of a given substance by 1 K.
- The heat capacity of a body is the heat energy required to raise the temperature of the body by 1 K.
- The factors that affect the amount of heat absorbed or liberated by a body are the temperature change, the mass of the body and the material making up the body.
- The amount of heat energy absorbed or liberated by a body can be calculated using
- $Q = mc\Delta T$.
- The high specific heat capacity of water is significant as water is used for cooling.
- A calorimeter is used in specific heat capacity and heat capacity experiments.
- The terms specific latent heat of fusion and specific latent heat of vaporisation relate to the energy required to melt and vaporise 1 kg of a substance at constant temperature.
- It is possible to calculate the energy (Q) required or liberated on a change of state for a given mass, m, of a substance using the equation $Q = mLf$ or $Q = mLv$.

UNIT 8 – Wave motion and Sound

- A wave transfers energy from one place to another as a series of vibrations.
- A wave pulse is a wave with no repeated vibrations.
- The particles in the medium vibrate from side to side; they do not travel through the medium with the wave.
- There are two types of wave, longitudinal and transverse.
- In a transverse wave the vibrations are perpendicular to the direction of wave motion.
- A transverse wave comprises a series of crests and troughs.
- In a longitudinal wave the vibrations are parallel to the direction of wave motion.
- A longitudinal wave comprises a series of compressions and rarefactions.

- In a compression the particles are closer together and in a rarefaction they are more spread out.
- The amplitude of a wave is the maximum displacement from the equilibrium position.
- The wavelength of a wave is the minimum distance from two identical points on adjacent waves (e.g. peak to peak).
- The frequency of a wave is the number of waves passing a given point per second.
- The time period of a wave is the time taken for one complete wave to pass a given point.
- Mechanical waves are waves that comprise a series of vibrations of matter.
- Examples of mechanical waves include water waves, sound waves and seismic waves.
- Electromagnetic waves comprise vibrations of electric and magnetic fields. No particles are required and so electromagnetic waves can travel through a vacuum.
- Electromagnetic waves form a family of waves called the electromagnetic spectrum.
- The wave equation is $v = f\lambda$.
- When waves bounce off a surface, this is called reflection.
- When waves travel from one medium to another, their speed may change and so they may bend. This is called refraction.
- Diffraction is the spreading out of waves when they pass through a gap or around an obstacle.
- Interference is when two or more waves pass through the same point and either add up or cancel each other out.
- Sound waves are mechanical longitudinal waves produced when objects vibrate.
- Sound waves travel through different media as a series of compressions and rarefactions.
- In general, sound travels faster in denser materials; however, the warmer the gas the faster the speed of sound through it.
- The amplitude of a sound wave affects its loudness and the frequency of the sound wave its pitch.
- A reflection of sound is called an echo and if several echoes are trapped inside a room or object a reverberation may be heard.

- The intensity of a sound wave is the energy received per square metre of a surface per second.
- Sound has many uses including SONAR and pre-natal scanning. Both rely on the sound waves reflecting and refracting off different materials.



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