**Science Reviewer**

**Forces and Motion**

**Definition of Terms:**

* **Measurement** – A way of comparing certain attribute of an object.
* **Direct Measurement** – Taking a measurement using standard tools or instruments **directly on the object** being measured.
* Measuring the **length of a table** using a **ruler or tape measure**.
* Measuring **temperature** using a **thermometer**.
* Measuring **mass** using a **weighing scale**.
* Measuring **time** using a **stopwatch** or **clock**.
* **Indirect Measurement** – Obtaining a measurement by **calculating or estimating** it using formulas, proportions or comparisons, especially when direct measurement is not possible.
* Finding the **height of a building** by using **shadow le**ngth and **applying similar triangles**.
* Measuring the **distance across a river** by applying **trigonometry** (e.g., using the Law of Sines).
* Calculating **area or volume** using measurements of length and width (e.g., area = length × width).
* Estimating **the speed of a moving** object using **distance ÷ time**.
* Using **Pythagorean Theorem** to find the diagonal of a **rectangle** when only length and width are measured.
* **Graphical Methods** – Graphical methods involve **drawing** vectors **to scale** and using **geometry** to find results.
* **Analytical Methods** – Analytical methods use **mathematical formulas** to calculate magnitude and direction of vectors.

**Definition of Terms:**

* **Fundamental Quantities** – The direct method that is related to length, mass, and time. Units are assigned to the measures of quantities in order to specify the standard wit which they are compared.
* **Fundamental Units** – Units assigned to the fundamental quantities.

**Physical Quantities:**

* **Scalar** – **A scalar** is a quantity that is described by **magnitude only** (just a number and unit, no direction).
* Speed (e.g., 60 km/h)
* Mass (e.g., 5 kg)
* Temperature (e.g., 30°C)
* Time (e.g., 10 seconds)
* **Vector** – **A** **vector** is a **quantity** that both **magnitude and direction.** Which is also represented by an arrow. The **length** of the arrow is proportional to the **magnitude** of the vector. The **tail** indicates the **starting** point of the vector. The **orientation** of the arrowhead shows the **direction**.
* Velocity (e.g., 60 km/h north)
* Force (e.g., 10 N to the right)
* Acceleration (e.g., 5 m/s² upward)
* Displacement (e.g., 20 meters east)
* **Composition of Vectors** – The process of finding the resultant of two or more concurrent vectors.
* **Resolution of Vectors** – The process of finding the components of a given vector.

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| **Scalar Quantities** | **Vector Quantities** |
| Have magnitude but no direction. | Have magnitude and direction. |
| * **Distance** – how much ground is covered, not where you’re headed. | * **Displacement** – how far and in which direction. |
| * **Speed** – how fast something moves, regardless of direction. | * **Velocity** – speed with a direction. |
| * **Mass** – amount of matter in an object. | * **Weight** – force of gravity in a specific direction. |
| * **Energy** – capacity to do work. | * **Acceleration** – rate of change of velocity, with direction. |
| * **Density** – mass per unit volume. | * **Force** – push or pull in a certain direction. |
| * **Power** – rate at which work is done. | * **Impulse** – change in momentum with direction. |
| * **Length, Area, Volume** – measures of space. | * **Pressure** – force per unit area, direction matters at surfaces. |
| * **Time** – flow of events. | * **Momentum** – mass in motion with a direction. |
| * **Temperature** – measure of heat. | * **Gravity** – directional pull toward a massive body like Earth. |
| * **Work** – force applied over a distance without specifying the direction of force. | * **Drag** – resistance force in the direction opposite of motion. |

* **Resultant** – A **resultant** **vector** is a **single** **vector** that has the **same** **effect** as **two** or **more** **vectors** **combined**.
* **Case 1 (Vectors in the Same Direction)**: Add the magnitudes directly.
* **Case 2 (Vectors in the Opposite Direction)**: Subtract the smaller magnitude from the larger.
* **Case 3 (Vectors in Different Directions)**: Use the **Triangle** and **Parallelogram** Method to find out.
* If you walk 3 meters north and then 4 meters east, your **resultant displacement** is the **diagonal** between those two directions — found using the **Pythagorean Theorem**:

* **Arrow** –An arrow is used to represent a vector.
* **Length** – **Magnitude** (how big or strong the quantity is). A longer arrow means a greater value.
* **Direction the Arrow Points** – Direction of the vector. For example, an arrow pointing up shows upward force or movement.
* **Tail** – Starting point of the vector
* **Head** – Direction where the vector ends or acts.

**How to Read Compass-Based Angles:**

* In physics and navigation, directions are often given in the form:
* This structure provides both **magnitude of deviation** (in degrees) and a **reference axis** (cardinal direction). To correctly interpret this kind of direction, it's important to understand what each part of the phrase signifies.
* When you hear something like “**25 degrees North of East**,” it means you start from **the East direction** and then turn **25 degrees toward the Nort**h. You're not starting from the North — you're moving from East in the direction **toward North**.
* All angles are measured **counterclockwise from East**, unless otherwise specified.
* How to Interpret the Direction:
* **Step 1**: **Identify the base direction** (the one after the word "of"). This is your starting axis.
* **Step** 2: Locate **the angle** and determine how far to rotate.
* **Step** 3: Determine **the direction of rotation** toward the first direction (the one before "of").
* **Step** 4: Apply **the angle rotation** starting from the base direction, toward the specified direction.
* **Step 5:** The result is a unique direction somewhere between the base and the turn direction.

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| * **General Format** - [angle] [direction 1] of [direction 2] * This means **you start from [Direction 2]**, then **rotate [X degrees] toward [Direction 1]**. * If you are turning **clockwise** from the base direction, you **add** the angle to the base direction. * If you are turning **counterclockwise** from the base direction, you **subtract** the angle from the base direction. | | **Direction:** | **Angle:** |
| **Example 1:** 25° North of East   * Start from **East** (90°) * Turn **25° toward North** (upward) * Final angle = | **Example:** 30° East of North   * Start from **North** (0°) * Turn **30° toward East** (right) * Final angle = | East | 0° or 360° |
| North | 90° |
| West | 180° |
| South | 270° |

**Graphical Method:**

* **Triangle Method** - Vectors are placed head-to-tail; the resultant connects start to end. The given vectors are drawn consecutively to form two sides of a triangle. The third side is the sum of the two vectors.
* **Step 1:** Draw the first vector to scale in the correct direction.
* **Step 2**: At the **tip of the first**, draw the second vector starting from there.
* **Step 3**: Draw the **resultant vector** (R) from the **start of the first** to the **end of the second**.
* **Step 4**: Measure length and angle of resultant (if needed).
* **Application**: Used when two vectors (e.g., force or velocity) act in different directions. It helps find the single equivalent (resultant) vector.
* **Parallelogram Method** - Two vectors originate from the same point; the diagonal is the resultant. The given vectors are drawn from the same point. Draw a parallelogram with these two vectors as sides. The diagonal of the parallelogram from the same point of origin is the sum of the vectors.
* **Step 1**: Draw both vectors to scale from a common origin.
* **Step 2**: Draw lines parallel to each vector to form a parallelogram.
* **Step 3**: Draw the diagonal from the common origin to the opposite corner; this is the resultant.
* **Step 4**: Measure the diagonal’s length and angle (if needed).
* **Application**: Commonly used in physics when two forces act simultaneously on the same object from one point.
* **Polygon Method** - Multiple vectors are connected head-to-tail; resultant connects start to final tip.
* **Step 1**: Draw the first vector to scale in its direction.
* **Step 2**: From the tip of the previous vector, draw the next vector.
* **Step 3**: Continue connecting all vectors head-to-tail.
* **Step 4**: Draw the resultant vector from the start of the first to the tip of the last vector.
* **Application**: Used when more than two forces or velocities act sequentially on a body. This method simplifies complex vector addition.

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| **Example:** |  |
| Find by the graphical method (polygon and parallelogram) the resultant of the following force vectors acting on an object. |  |
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| Vectors are placed **tip-to-tail**:   * **F1** (blue) goes west * **F2** (green) starts from the head of F1, goes N25°E * **F3** (orange) continues from F2’s head, going S10°E   The **red vector** is the **resultant** from start to end. | * **F1** and **F2** (blue and green) are placed tail-to-tail. * A **parallelogram** is formed using copies (faint green and blue). * The **purple vector** shows **F1 + F2**. * The **black vector** is the **final resultant** after adding **F3**. |

**Analytical Method:**

* **Pythagorean Theorem** – Used when vectors form a right triangle (90° angle between them).
* **Step 1**: Square the magnitudes of the two perpendicular vectors.
* **Step 2**: Add the squares together.
* **Step 3**: Take the square root of the sum to find the resultant.
* **Step 4**: Use trigonometry (e.g., tan⁻¹) to find direction if needed.
* **Application:** When motion occurs in two perpendicular directions, such as moving east and then north. Helps find the total displacement or net force.

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|  | **Example Problem:**  A person walks:   * 3 meters east (this is side A), then * 4 meters north (this is side B).   Where: |  |
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* **Law of Sines** - Used when a triangle has **non-right angles**.
* **Step 1**: Use the formula

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|  | **Example Problem:**  In triangle ABC: |  |
| * **Calculate the left side:** * **Solve for** * **Use Inverse Sine** | |

* **Step 2**: Rearrange the equation to solve for unknown sides or angles.
* **Step 3**: Apply known values and solve using a calculator.
* **Step 4**: Use it when angle-side relationships are known (SAS or ASA cases).
* **Application**: Helps solve vector triangles when you don’t have a right angle, such as when two forces act at an arbitrary angle.
* **Law of Cosines** – Used when you know two sides and the included angle.
* **Step 1:** Use the formula

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* **Step 2**: Plug in the magnitudes of the vectors and the angle between them.
* **Step 3**: Compute the value of by solving the equation, whereas is the resultant vector.
* **Step 4**: Use inverse cosine to find angle (if needed).
* **Application**: Perfect for non-right triangle vector problems, like two forces pulling at a specific angle that’s not 90°.

**Types of Motion:**

* Movement of an object defines as a continuous change of a place or position.
* **Rectilinear Motion** – Rectilinear motion is the movement of an object along a **perfectly straight path**, where its position **changes** in a **single** **dimension** over time, such as **a car moving down a straight road** or a **ball dropped vertically**.
* **Curvilinear Motion** – Curvilinear motion refers to the **motion of an object along a curved path** in space, where **both the direction and possibly the speed continuously change**, like a **stone** thrown in a **parabolic** **arc** or a **car turning around** a bend.
* **Angular Motion** – Angular motion describes the **rotation of a body around a fixed point or axis**, with **its position defined by angles** rather than linear distance, such as the **swinging of a clock** **hand** or the **motion of a seesaw**.
* **Rotational Motion** – Rotational motion is **the circular movement of all points on a body around a fixed central axis**, where **each point traces a circular path** and **maintains a constant distance** **from the axis**, like a **spinning fan** or a **rotating wheel**.
* **Oscillatory or Harmonic Motion** – Oscillatory or harmonic motion is **repetitive back-and-forth movement** **around a central equilibrium position**, typically under a restoring force proportional to displacement, as seen in a **swinging pendulum** or a **vibrating guitar string**.

**Fundamental Branches of Motion Study:**

* **Mechanics** – Mechanics is the **branch of physics** that **studies** the **motion of objects** and the **forces** that **cause** or **change** this **motion**, including concepts like **displacement**, **force**, **mass**, and **energy**.
* **Kinematics** – Kinematics is the **study of how objects move**, focusing on **position**, **velocity**, and **acceleration**, **without** **considering** the **forces** that **cause** the **motion**.

**Reference Frame:**

* **Reference Frame** – A reference frame is a **fixed** or **moving point of view** (often with a coordinate system) from **which** an **observer measures** and **describes the motion of objects**, like watching a **train move from a platform** versus **inside the train**.

**Describing Motion Through Position:**

* **Distance** – Distance is the **total length** of the **actual path traveled by an object** during motion, **regardless of direction**, and is **always a positive scalar** quantity.

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| **Distance Formula:** |

* **Displacement** – Displacement is the **shortest straight-line distance** between an **object’s initial and final positions**, including **direction**, making it a **vector** quantity that can be **positive**, **negative**, or **zero**.

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| **Displacement:**  **s** = displacement (m)  **u** = initial velocity (m/s)  **a** = acceleration (m/s²)  **t** = time of travel (s) | **Or** |

**Rate of Motion and Directional Change**

* **Speed** – Speed is **the rate at which an object covers distance over time**, **without** considering **direction**, and is measured in units like **meters per second (m/s).**
* **Average Speed** – Average speed is the total distance traveled divided by the total time taken, giving an overall rate of motion without regard to varying speeds or direction.
* **Instantaneous Speed** – Instantaneous speed is the speed of an object at a specific moment in time, like what a car’s speedometer shows at any given instant.

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| **Speed Formula**   * **Speed** = how fast an object moves, without direction (scalar) * **Distance (d)** = total path length traveled (m) * **Time (t)** = total time taken for the motion (s) |  |

* **Velocity** – Velocity is **the rate of change of displacement over time** **and includes both magnitude (speed) and direction**, making it a **vector quantity**.
* **Final Velocity** – Final velocity is the **velocity of an object at the end of a time interval**, after it has accelerated or decelerated.
* **Average Velocity** – Average velocity is the **total displacement** divided by the **total time taken**, showing the overall rate and direction of motion.

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| **Velocity Formula:**   * **Velocity (v)** = rate of change of displacement with direction (vector) * **Displacement (s)** = shortest straight-line distance between start and end points, with direction (m) * **Time (t)** = duration of motion (s) | |  |
| **Final Velocity Formula:**  **Vi** = initial velocity  **a** = acceleration  **t** = time  **Vf** = final velocity | **Or** | |
| **Average Velocity Formula:**   * **Note:** Different from average speed (which uses distance instead of displacement). | | |

* **Acceleration** – Acceleration is the **rate of change of velocity with respect to time**, describing how quickly an object speeds up, slows down, or changes direction.

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| **Acceleration Formula:**  **a** = acceleration (rate of velocity change) (m/s²)  **v** = final velocity (m/s)  **u** = initial velocity (m/s)  **t** = time taken for change (s) | **Or** |

* **Deceleration** - Deceleration is a type of acceleration where the velocity of an **object decreases over time**, meaning the object is slowing down.

**Measuring Speed Over Time:**

* **Average Speed** – Average speed is **the total distance traveled divided by the total time taken**, giving an **overall rate of motion** without regard to varying speeds or direction.
* **Instantaneous Speed** – Instantaneous speed is **the speed of an object** at a **specific moment in time**, like what a **car’s speedometer shows** at any given instant.

**Newtons First Law of Motion:**

* **Inertia –** From Galileo’s initial idea, Isaac Newton developed the concept of Inertia which states:*“An object at rest remains at rest and that an object in constant motion remains to be in that state of motion unless acted upon by an external force.”*
* Objects do not accelerate on their own; instead, a net external force acts on them to oppose the tendency of resistance to that the objects with accelerate.
* Inertia is a property that is possessed by any material that has mass. The more massive an object is, the more inertia it has.
* Mass is commonly interchanged with weight but they are two different quantities
* **Mass**: Amount of matter an object contains.

1. Scalar and constant
2. Uses kilograms (kg) as a unit of measurement

* **Weight**: Amount of gravitational force than an object experiences.

1. Vector and non-constant
2. Uses newton (N) as a unit of measurement

* On Earth, mass and weight are directly proportional to each other. If the mass of an object is doubled, it’s weight will also be doubled. If its mass is halved, it’s weight will also be halved. But does not mean they are the same.

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| **Equation:** | **Other Information**:   * If the pull of gravity changes, its mass does not. |
| **Equation Simplified:** | **Equation Example:** |

* Mass remains to be constant for any object regardless of location, but weight changes depending on gravity.

**Laws of Motion**

**Newtons First Law (ADHD Version)**:

* **Law of Inertia** – States that an **object** at **rest** will **remain** at **rest**, and an object in **motion** will **continue** **moving** at a constant velocity in a straight line, **unless** **acted** **upon** by an external unbalanced force.
* **Inertia** – is the tendency of a body at rest to remain at rest and of a body in motion to continue in motion with constant velocity.
* **Mass** – A **measure** of an **object’s** **inertia**, representing **how** **much** it **resists** **changes** in its state of motion; it is **related** to the **amount** of matter in an **object** but not the **same** as **density**.
* **Weight** – The force exerted on an object due to gravity, calculated as the product of its mass and the acceleration due to gravity
* **Kinetics** – The branch of mechanics that studies how forces affect the motion of objects, including changes in speed and direction (acceleration).
* **Dynamics** – The field of physics that focuses on the effects of forces and torques on the motion of objects or systems.
* **Net Force** – The overall force acting on an object, found by adding all the individual forces vectorially; it determines the object’s acceleration and direction of motion.

**Newtons Second Law of Motion:**

* **Law of Acceleration** –When a net external force is applied on a body, the body acquires an acceleration which is directly proportional to the net force applied to it and inversely proportional to its mass.
* **Newton** – is the force which gives a mass of 1kg an acceleration of 1m/s2
* **Dyne** – is the force which gives a mass of 1g an acceleration of 1cm/s2
* When a net force acts on an object, the object Newtons Second Law, or the law of acceleration, investigates the relationship between force and mass in the object’s acceleration.

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| **Equation:** | **Equation Simplified:** |
| **Equation That Acceleration Caused:** |  |

**Newtons Third Law of Motion:**

* **Law of Interaction or Action** - *“For every action, there is an equal and opposite reaction.”* For every force exerted by a body on a second body, the second body exerts an equal and opposite force on the first.
* A rocket pushing on the gas: gas pushing on the rocket.
* Tires pushing on the ground, ground pushing on the tires.
* Gloves pushing on the face, face pushing on the gloves.
* A bird hitting the windshield of a car, windshield hitting the bird.
* **Action Force**: A pair of forces.
* **Reaction Force**: Is present in interacting objects.
* When two objects interact, the first object exerts a force (action force) on the second object. Similarly, the second object also applies a force that is equal in magnitude but in the opposite direction (reaction force).

**Forces:**

* **Force** – Is a push or pull that can cause an object to start moving, stop moving or change its direction or speed. Force is an interaction that can cause a change in an object’s state of motion.
* ***Examples:*** A push or pull such as applying brakes on a car or lifting an object.
* ***Effects:*** Force can cause an object to accelerate (change speed or direction), decelerate (slow down) or stop.
* **Contact Forces** – Contact forces require direct physical contact between objects to exert their effect.
* **Frictional force** – Opposes motion when objects rub against each other
* **Normal force** – The force exerted by a surface on an object in contact with it
* **Tension** – Force transmitted through a rope, string or wire when pulled taut
* **Air Resistance (Drag)** – A frictional force exerted by the air on an object moving through it
* **Applied Force** – A force exerted by a person or an object on another object
* **Spring Force** – The force exerted by a spring when compressed or stretched
* **Frictional Force due to Contact** – When solid object is in contact with another solid surface, the force exerted by the surface that opposes the motion of the first object
* **Tension Force due to Contact** – Force transmitted through wire, rope or string.
* **Non-Contact Force** – Non-contact forces can act at a distance.
* **Gravitational Force** – The force of attraction between any two objects with mass
* **Electromagnetic Force** – The force between electrically charged particles, including static electricity and magnetism
* **Strong Nuclear Force** – The force that binds the protons and neutrons together in the nucleus of an atom
* **Weak Nuclear Force** – The force responsible for radioactive decay
* **Magnetic Force** – The force exerted by magnets on other objects
* **Electrostatic Force-** The force between charged particles