Physics 11 Dynamics Unit Summary of Key Ideas

Key Ideas: Force

Force is a push or a pull, or an action capable of giving rise to acceleration. The unit of force is the Newton (N).

- $1\ \text{N} = 1\ \frac{kg \cdot m}{s^2}$

Force is a vector quantity that has both a magnitude and a direction.

Force can be exerted on an object by some other object.

The net force of an object is the vector sum of all forces acting on it.

Some types of force:

- F_g Gravitational force is the force of gravity on an object.
- F_N Normal force is the force that a surface exerts on an object with which it is in contact.
- F_f Frictional force is the force that opposes the motion between two surfaces in contact.
- F_T Tension is the force that a rope exerts on an object when it pulls on the object.
- F_S Elastic force is the force that a spring exerts on an object attached to the spring.

The force acting on an object is represented using an arrow:

- The length of the arrow is proportional to the magnitude of the force, and the direction of the arrow gives the direction of the force.

Weight is the gravitational force on an object, mass is a measure of the tendency of an object to resist a change in its motion.

- Mass is the amount of matter.
- Mass is an inherent property of an object and is independent of the surroundings of the object.
- Mass is a scalar quantity, and the total mass is the algebraic sum of each mass.

Key Ideas: Gravity

Newton's law of universal gravitation: Gravitational force:

- Every object in the universe exerts an attractive force on every other object. Mass attracts mass.
- The gravitational force between any two objects is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.
- The direction of the gravitational force is along the line joining the centres of two objects.
- The gravitational force exerted by each object has equal magnitude, but opposite direction

$$F_g = \frac{GMm}{r^2} \qquad G = 6.67 \times 10^{-11}\ \frac{\text{Nm}^2}{kg^2}$$

- G = universal gravitational constant
- M, m = masses of the two objects in kg
- r = separation distance between the centres of two objects in m

Weight and gravitational field strength :

- The weight of an object is the gravitational force exerted on the object by an astronomical body and varies with location. Weight is a vector quantity directed toward the centre of an astronomical body.

• The gravitational field strength varies with location. The weight of an object is equal to the product of the object's mass and the gravitational field strength.

$$F_g = mg$$

• g = gravitational field strength (equivalent to the acceleration due to gravity)

• The gravitational field strength value we will use in calculations on or near the earth is $9.80\ {}^{N}/_{kg}$

Key Ideas: Normal Force

Normal force is the force that a surface exerts on an object with which it is in contact. The direction of the normal force is perpendicular to the contact surface.

If an object rests on a horizontal surface and there are no vertically-acting forces except the object's weight and the normal force, the magnitude of the normal force is equal to the object's weight.

If other forces are applied to the object in the vertical direction, the magnitude of the normal force is not equal to the object's weight.

• The apparent weight is the force that an object exerts on the platform of a scale with which it is in contact. In other words, the apparent weight is the normal force exerted on the object by the platform of the scale.

• If a scale and the object on it have no acceleration, the scale registers the true weight of the object, mg.

• If a scale and the object on it are accelerating, the apparent weight is not equal to the true weight. The acceleration is positive if the scale and the object accelerates upward, and the acceleration is negative if the scale and the object accelerates downward.

• If a scale and the object on it fall freely, the acceleration is $9.8\ {}^{m}/_{s^2}$, and the apparent weight is zero. In this situation, the object experiences apparent "weightlessness".

Key ideas: Friction

Frictional force is the force that opposes the motion between two surfaces in contact.

The magnitude of the frictional force depends on the normal force and the nature of the surfaces. The frictional force is independent of the contacting surface area and the sliding speed.

The direction of the frictional force is parallel to the surface and opposite to the direction of motion.

As a force is applied to an object along a surface, the frictional force increases to a certain maximum, decreases somewhat when the object begins to move, and then remains constant.

Static friction

• Static friction is the frictional force that opposes the start of motion.

• The coefficient of static friction is a constant of proportionality for a given pair of contacting surfaces before motion begins.

• Static friction increases from zero (when no force is applied) to a maximum value just before motion begins.

Kinetic friction

• Kinetic friction is the frictional force between surfaces in relative motion.

• The coefficient of kinetic friction is a constant of proportionality for a given pair of contacting surfaces in relative motion.

Key Ideas: Tension

Tension is the tendency of a rope, wire, cable, or other solid object to be pulled apart due to forces that are applied at each end

The force exerted at one end of a rope is transmitted undiminished to the other end of the rope if the mass of the rope is ignored

Key Ideas: Hooke's Law

When a spring is stretched or compressed by a force applied to it, the spring exerts an oppositely-directed force of equal magnitude, acting to return it to its normal length.

The applied force required to stretch or compress a spring is directly proportional to the displacement of the spring.

$F_{applied} = kx \qquad F_{spring} = -kx$ x=displacement from nominal position, k=spring constant

A spring constant is a measure of the stiffness of a particular spring. The unit of spring constant is N/m.

A stiff spring has a large value of a spring constant, and a soft spring has a small value

Key Ideas: Free Body Diagrams

A free-body diagram is a diagram that represents an object and the forces acting on it.

Only the forces acting on the object appear in a free-body diagram. A free-body diagram is very helpful to solve problems involving the forces on one or more objects.

Key Ideas: Newton's Laws

Newton′s three laws of motion are the basic laws describing motion.

Newton′s first law of motion (Law of inertia):

- Inertia is the tendency of an object to resist a change in its motion.
  - Mass is a measure of the inertia of an object.
  - Newton's first law states that if no net force acts on it, an object at rest remains at rest, and an object in motion remains in motion in a straight line at constant velocity.

Newton′s second law of motion :

- Newton's second law states that the net force acting on an object is equal to the product of the mass and the acceleration of the object. The direction of the net force is the same as that of the acceleration.

$F_{net} = ma$

Newton′s third law of motion (action-reaction law):

- Newton's third law states that when an object exerts a force on another object, the second object exerts a force on the first object that is equal in magnitude but opposite in direction.

$F_{AonB} = -F_{BonA}$