**IDX G9 PHYSICS S STUDY GUIDE ISSUE 2**

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**3.3 Free Fall**

* **Acceleration Due to Gravity (g):**
  + **Average Value:** (downward, Earth’s surface).
  + **Free Fall:**
    - Motion where air resistance is negligible, and only gravity acts on the object.
    - **Symbol:** .
* **Air Resistance:**
  + Objects falling through air experience fluid friction.
  + **Effect on Different Objects:** Air resistance affects lighter objects (e.g., feather) more than heavier ones (e.g., rock), making them fall slower.
* **Object Dropped from Rest:**
  + **Equations of Motion:**
    - **Displacement:** , ,
    - **Final Velocity:**
* **Objects Launched Upward:**
  + **Initial Velocity:** Must be non-zero and directed upward for upward motion.
  + **Constant Acceleration:** (or , depending on chosen positive direction).
  + **Velocity Changes:**
    - **Upward Motion:** Velocity decreases to zero at maximum height.
    - **Downward Motion:** Velocity increases as the object falls back down.

### ****4.1 Force and Motion****

#### ****Introduction to Force****

* + **Definition**: A force is a push or pull on an object that can change the object’s velocity or cause deformation.
    - **Symbol**:
    - **Unit**: Newton (N) or kg·m/s²
    - **Types of Interaction**:
      * **System**: The object receiving the force.
      * **Agent**: The object applying the force.
    - **Example**: A book on a table exerts a downward force on the table (system: table, agent: book) while the table exerts an upward force on the book.
* **Force Representation**:
  + **Vector Representation**: Force is a vector, represented by arrows in diagrams.
  + **Free Body Diagram (FBD)**:
    - raw a particle at the center of mass.
    - Tail of the arrow is the system; head shows force direction.
    - Label to indicate the type of force.

#### ****Types of Forces****

* + **Contact Forces**: Result from physical contact between objects.
  + **Field Forces**: Act over a distance without physical contact (e.g., gravity).
* **Common Forces**:
  + **(Gravity)**: The force of attraction between Earth and an object.
    - **Direction**: Toward Earth’s center.
    - **Magnitude**: (g ≈ 9.8 m/s² on Earth).
  + ​ **(Normal Force)**: The perpendicular contact force exerted by a surface.
    - **Direction**: Perpendicular to the surface.
  + ​ **(Spring Force)**: The force exerted by a compressed or stretched spring.
    - **Direction**: Opposite the displacement.
  + **(Tension Force)**: The pull exerted by a taut string, rope, or cable.
    - **Direction**: Along the string, away from the object.
  + ​ **(Friction Force)**: The force opposing motion between surfaces in contact.
    - **Direction**: Parallel to the surface and opposite to motion.
  + **Thrust**: A general force moving objects (e.g., rockets, planes).
    - **Direction**: Same as the object’s acceleration.

#### ****Gravity and Weight****

* + **Gravity**: A field force that depends on the gravitational pull between two masses.
  + **Weight (W)**: The gravitational force acting on an object’s mass.
    - **Formula**:
    - **Direction**: Downward (toward Earth).

#### ****Combining Forces in 1 Direction****

* + **Net Force ()**: The vector sum of all forces acting on an object.
    - **Same Direction**: Add magnitudes.
    - **Opposite Direction**: Subtract magnitudes.
    - **Formula**:
    - (same direction)
    - (opposite directions)

#### ****Newton’s Laws of Motion****

* + **Newton’s First Law (Law of Inertia)**:
    - An object remains at rest or in constant motion unless acted upon by a net external force.
    - **Inertia**: The resistance of an object to change in its motion; directly proportional to mass.
  + **Newton’s Second Law (Law of Acceleration)**:
    - The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.
    - **Formula**:
    - **Units**: kg (mass), N (force), m/s² (acceleration).
  + **Newton’s Third Law (Law of Action- Reaction pairs):**
    - If object A exerts force on object B, then object B exerts an equal but opposite force on force A
    - Not interaction pairs

**4.3 Interaction Forces**

#### ****Interaction pairs (action-reaction pair of forces)****

* + 2 forces in opposite directions and have equal magnitude
  + 2 forces same type and opposite system
  + Forces always come in pairs
    - Action-reaction pair= Newton’s Third Law
* Balanced forces
  + Act on the same object
  + Can be added together (Fnet=0)
  + Can be two different kinds of forces
  + Will not change the motion of an object
* Interaction pairs
  + Act on two different objects
  + Cannot be added together
  + Same kind of forces
  + Might change the motion of an object (if no force can balance them)

**Check Your Understanding Questions**

1. **What is the magnitude and direction of acceleration for an object in free fall near Earth's surface?**
2. **How does air resistance affect the motion of a falling object, and why do heavier objects tend to fall faster than lighter ones in the presence of air resistance?**
3. **If an object is dropped from rest, what formula can be used to determine its displacement after a given time?**
4. **What is a free-body diagram, and how does it represent forces acting on a system?**
5. **Describe the difference between contact forces and field forces and give one example of each.**
6. A suitcase sits on a stationary airport luggage cart. Draw a free -body diagram for each object and specifically indicate any interaction pairs between the two.
7. When a softball with a mass of 0.18 kg is dropped, its acceleration toward Earth is equal to g, the acceleration due to gravity. What is the force on Earth due to the ball, and what is Earth’s resulting acceleration? Earth’s mass is 6.0 × 1024 kg.
8. A 50.0-kg bucket is being lifted by a rope, The rope will not break if the tension is 525N or less. The bucket started at rest, and after being lifted 3.0 m, it is moving at 3.0 m/s. If the acceleration is constant, is the rope in danger of breaking?
9. You are helping to repair a roof by loading equipment into a bucket that workers hoist to the rooftop. If the rope is guaranteed not to break as long as the tension does not exceed 450 N and you fill the bucket until it has a mass of 42 kg, what is the greatest acceleration that the workers can give the bucket as they pull it to the roof?
10. Diego and Mika are trying to fix a tire on Diego’s car, but they are having trouble getting the tire loose. When they pull together, Mika with a force of 23 N and Diego with a force of 31 N, they just barely get the tire to budge. What is the magnitude of the strength of the force between the tire and the wheel?