General Physics

Lecture Two / Theoretical

Newton's   Laws of Motion, Weight, Momentum, and Work

First stage

Dr. Ahmed Najm Obaid

Assis. Lect. Amin Kadhum Awad

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Newton's Laws of Motion

In 1686, the English scientist Isaac Newton presented three principles that even today are recognized as fundamental laws of motion.

Newton's first law: Inertia—A body will remain at rest or will continue to move with constant velocity in a straight line unless acted on by an external force.

The property of matter that acts to resist a change in its state of motion is called inertia.

At Rest

In Motion
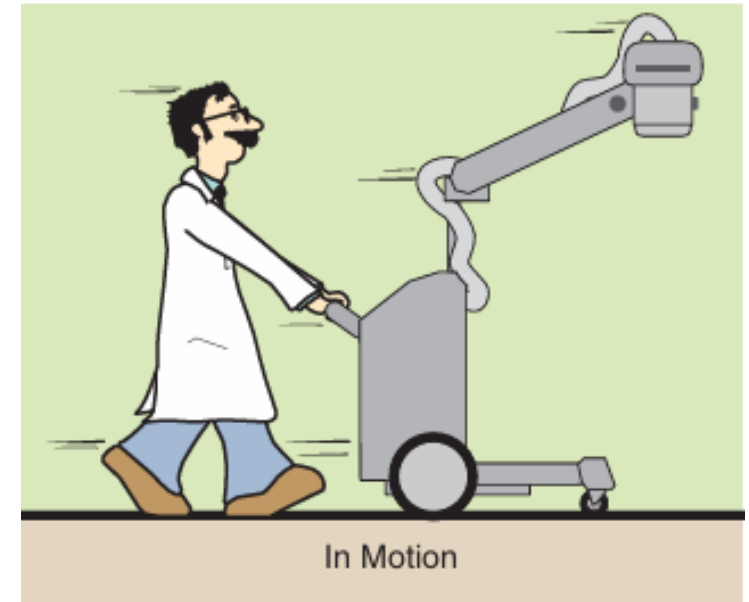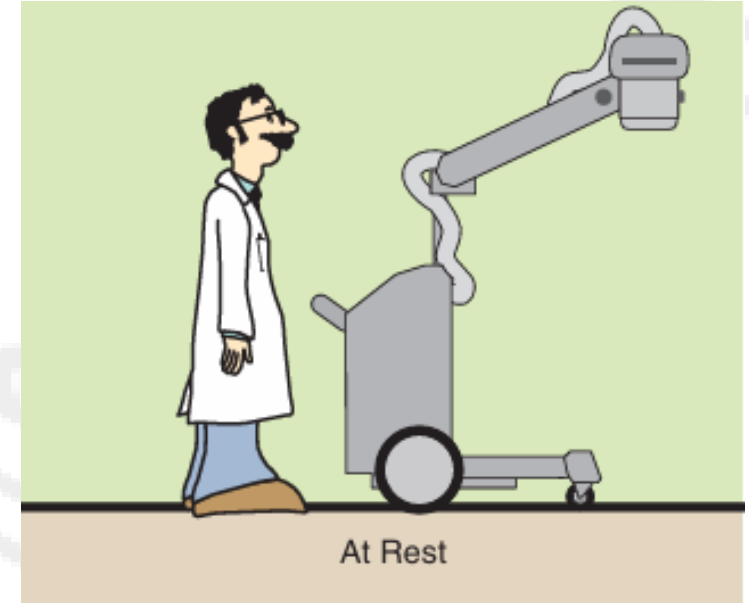
Newton's second law: Force—The force (F) that acts on an object is equal to the mass (m) of the object multiplied by the acceleration (a) produced.
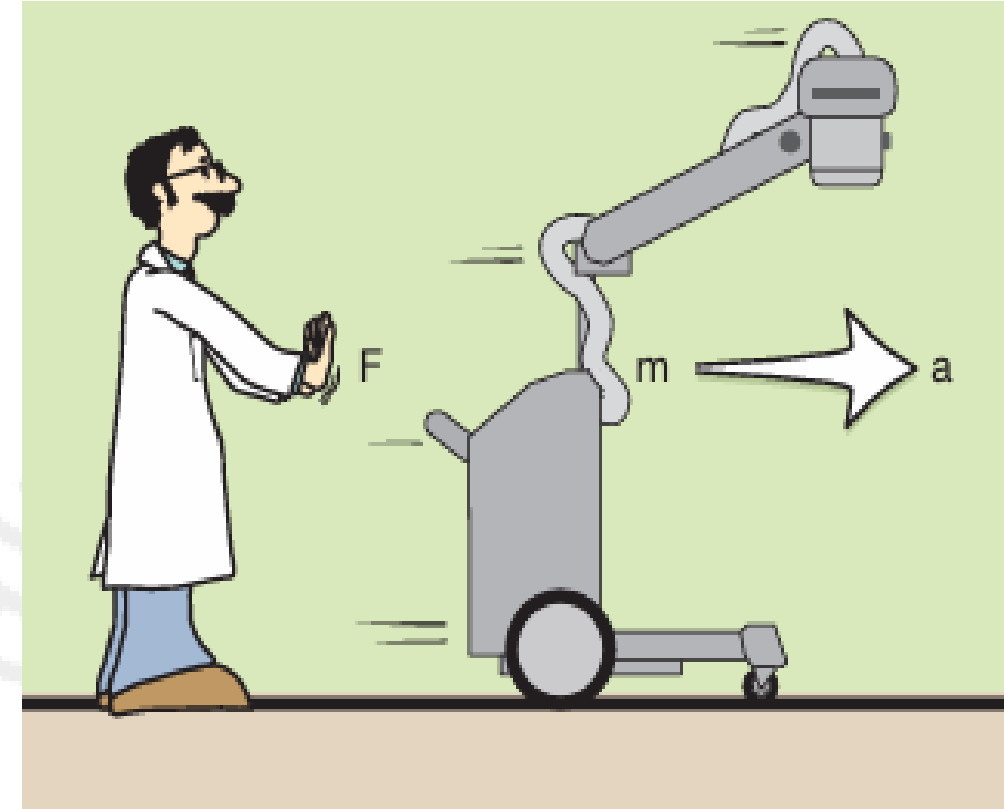
Force

$$F = ma$$

The SI unit of force is the newton (N).

Question: Find the force on a 55-kg mass accelerated at 14 m/s².

Answer: $F = ma$
(55 kg) (14 m/s²)
770 N

Question: For a 3600-lb (1636-kg) Ford Mustang to accelerate at 15 m/s², what force is required?

Answer: $F = ma$
(1636 kg) (15 m/s²)
24,540 N

Newton's third law: Action/reaction—For every action, there is an equal and opposite reaction.

3

Weight

Weight (Wt) is a force on a body caused by the pull of gravity on it. Experiments have shown that objects that fall to Earth accelerate at a constant rate. This rate, termed the acceleration due to gravity and represented by the symbol g, is 9.8 m/s² on Earth and 1.6 m/s² on the moon.
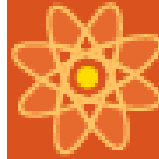
Weight

$$Wt = mg$$

Units of weight are the same as those for force: newtons and pounds.

Question: A student technologist has a mass of 75 kg. What is her weight on the Earth? On the moon?

Answer: Earth: g = 9.8 m/s²

$$Wt = mg$$
$$= 75 \text{ kg } (9.8 \text{ m/s}^2)$$
$$= 735 \text{ N}$$

Moon: g = 1.6 m/s²

$$Wt = mg$$
$$= 75 \text{ kg } (1.6 \text{ m/s}^2)$$
$$= 120 \text{ N}$$

4

Momentum

The product of the mass of an object and its velocity is called momentum, represented by p. The greater the velocity of an object, the more momentum the object possesses. A truck accelerating down a hill, for example, gains momentum as its velocity increases.

Momentum

$$p = mv$$

For example, say a problem asks you to calculate the momentum of a 15 kg object moving at 6 m/s North. Applying the steps above produces:

1. The mass, m, of the object is 15 kg.
2. The velocity, v, of the object is 6 m/s North.
3. Substituting these values into the momentum equation gives: $p = (15 \text{ kg})(6 \text{ m/s North})$.
4. Multiplying mass and velocity gives: $p = 90 \text{kg} \cdot \text{m/s North}$.

Work

Work, as used in physics, has specific meaning. The work done on an object is the force applied times the distance over which it is applied. In mathematical terms, the unit of work is the joule (J).
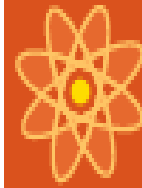
Work

$$W = Fd$$

Question: Find the work done in lifting an infant patient weighing 90 N (20 lb) to a height of 1.5 m.

Answer:

$$\text{Work} = Fd$$
$$= (90 \text{ N}) (1.5 \text{ m})$$
$$= 135 \text{ J}$$

Comprehensive Set of MCQs

1. **What is the acceleration due to gravity on Earth?**
    1. A) $9.8 \ m/s^2$
    2. B) $1.6 \ m/s^2$
    3. C) $10 \ m/s^2$
    4. D) $9.0 \ m/s^2$
    5. E) $8.5 \ m/s^2$

    Answer:

2. **What does weight (Wt) represent?**
    1. A) Mass of an object
    2. B) Force due to gravity
    3. C) Distance traveled
    4. D) Speed of an object
    5. E) Energy consumed

    Answer:

3. What is the unit of work in physics?

    1. A) Newton

    2. B) Joule

    3. C) Watt

    4. D) Pascal

    5. E) Volt

Answer:

4. What is momentum represented by?

    1. A) F

    2. B) m

    3. C) p

    4. D) v

    5. E) a

Answer:

5. Which of the following is true about objects falling to Earth?

    1. A) They accelerate at a variable rate

    2. B) They do not accelerate

    3. C) They accelerate at a constant rate

    4. D) They decelerate

    5. E) They float

    Answer:

6. What is the formula for calculating work?

    1. A) Force + Distance

    2. B) Force - Distance

    3. C) Force × Distance

    4. D) Force / Distance

    5. E) Force² × Distance

    Answer:

7. Which of the following factors does momentum depend on?

    1. A) Mass only

    2. B) Velocity only

    3. C) Both mass and velocity

    4. D) Distance

    5. E) Time

    Answer:

8. What is the gravitational acceleration on the moon?

    1. A) 9.8 m/s²

    2. B) 1.6 m/s²

    3. C) 0 m/s²

    4. D) 3.7 m/s²

    5. E) 4.9 m/s²

    Answer:

9. If an object is at rest, what is its momentum?

    1. A) Zero

    2. B) Constant

    3. C) Infinite

    4. D) Variable

    5. E) Negative

    Answer:

10. Which of the following describes a force?

    1. A) A push or pull on an object

    2. B) The mass of an object

    3. C) The distance traveled

    4. D) The energy consumed

    5. E) The speed of an object

    Answer:

11. What is the work done if a force of 10 N is applied over a distance of 5 m?
1. A) 50 J
2. B) 5 J
3. C) 15 J
4. D) 10 J
5. E) 25 J
Answer:

12. What happens to the weight of an object on the moon compared to Earth?
1. A) It is the same
2. B) It is greater
3. C) It is less
4. D) It doubles
5. E) It triples
Answer:

13. What is the effect of increasing the mass of an object on its momentum?

1. A) Momentum decreases
2. B) Momentum remains the same
3. C) Momentum increases
4. D) Momentum becomes zero
5. E) Momentum fluctuates

Answer:

14. What is the relationship between force, mass, and acceleration?

1. A) F = m + a
2. B) F = m - a
3. C) F = m × a
4. D) F = m / a
5. E) F = a / m

Answer: