Ministry of higher education

and scientific research

Al-Mustaqbal University

Lecture One / General physics

Standard Units of Measurement
Newton's Laws of Motion

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Measurement

Physics is the study of interactions of matter and energy in all their diverse forms. Similar to all scientists, physicists strive for exactness or certainty in describing these interactions. They try to remove the uncertainties by eliminating subjective descriptions of events. Assuming that all measurements are correctly made, all observers who use the methods of physics will obtain exactly the same results. In addition to seeking certainty, physicists strive for simplicity; therefore, only three measurable quantities are considered basic. These base quantities are mass, length, and time, and they are the building blocks of all other quantities.

The secondary quantities are called derived quantities because they are derived from a combination of one or more of the three base quantities. For example, volume is length cubed (l^3), mass density is mass divided by volume (m/l^3), and velocity is length divided by time (l/t).

Units

Every measurement has two parts: a magnitude and a unit. For example, the SID is 100 cm. The magnitude, 100, is not meaningful unless a unit is also designated. Here, the unit of measurement is the centimeter.

SI Prefixes

Factor	Prefix	Symbol
10^{18}	Exa	E
10^{15}	Peta	P
10^{12}	Tera	T
10^{9}	Giga	G
10^{6}	Mega	M
10^{3}	Kilo	k
10^{2}	Hecto	h
10^{1}	Deca	da
10^{-1}	Deci	d
10^{-2}	Centi	c
10^{-3}	Milli	m
10^{-6}	Micro	μ
10^{-9}	Nano	n
10^{-12}	Pico	p
10^{-15}	Femto	f
10^{-18}	Atto	a

SI Base Units

Quantity	Name	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A

Special Quantities of Radiologic Science and Their Associated Special Units

	CUSTOMARY UNIT			SI UNIT	
Quantity	Name		Symbol	Name	Symbol
Exposure	roentgen		R	air kerma	Gy_a
Absorbed dose	rad		rad	gray	Gy_t
Effective dose	rem		rem	seivert	Sv
Radioactivity	curie		Ci	becquerel	Bq
Multiply	R	by	0.01	to obtain	Gy_a
Multiply	rad Gy	by	0.01	to obtain	Gy_t
Multiply	rem	by	0.01	to obtain	Sv
Multiply	Ci	by	3.73×10^{10}	to obtain	Bq
Multiply	R	by	2.583×10^{-4}	to obtain	C/kg

Question: The dimensions of a box are 30 cm × 86 cm × 4.2 m. Find the volume.

Answer: Formula for the volume of an object:

$V = \text{length} \times \text{width} \times \text{height}$ or $V = lwh$

Because the dimensions are given in different systems of units, however, we must choose only one system. Therefore,

$V = (0.3\ \text{m})(0.86\ \text{m})(4.2\ \text{m})$
$= 1.1\ \text{m}^3$

Question: Find the mass density of a solid box 10 cm on each side with a mass of 0.4 kg.

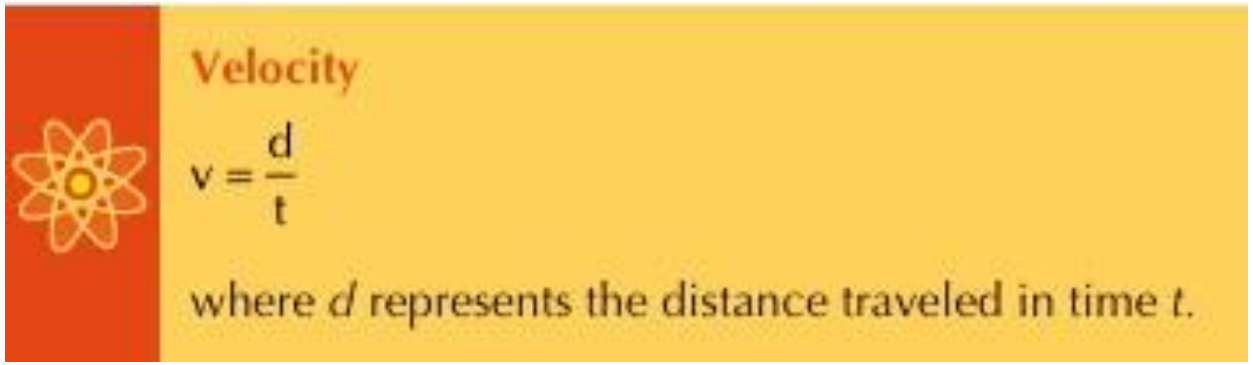
Answer: $D = \text{mass/volume}$ (change 10 cm to 0.1 m)
$= 0.4\ \text{kg}/(0.1\ \text{m} \times 0.1\ \text{m} \times 0.1\ \text{m})$
$= 0.4\ \text{kg}/0.001\ \text{m}^3$
$= 400\ \text{kg/m}^3$

Mechanics

Mechanics is a segment of physics that deals with objects at rest (statics) and objects in motion (dynamics).

Velocity

The motion of an object can be described with the use of two terms: velocity and acceleration. Velocity, sometimes called speed, is a measure of how fast something is moving or, more precisely, the rate of change of its position with time. The velocity of a car is measured in kilometers per hour (miles per hour). Units of velocity in SI are meters per second (m/s). The equation for velocity (v) is as follows



The velocity of light is constant and is symbolized by c: $c = 3 \times 10^8$ m/s.

Question: What is the velocity of a ball that travels 60 m in 4 s?

Answer: $v = \frac{d}{t}$

$v = 60 \text{ m}/4 \text{ s},$

$v = 15 \text{ m/s}$

Question: Light is capable of traveling 669 million miles in 1 hour. What is its velocity in SI units?

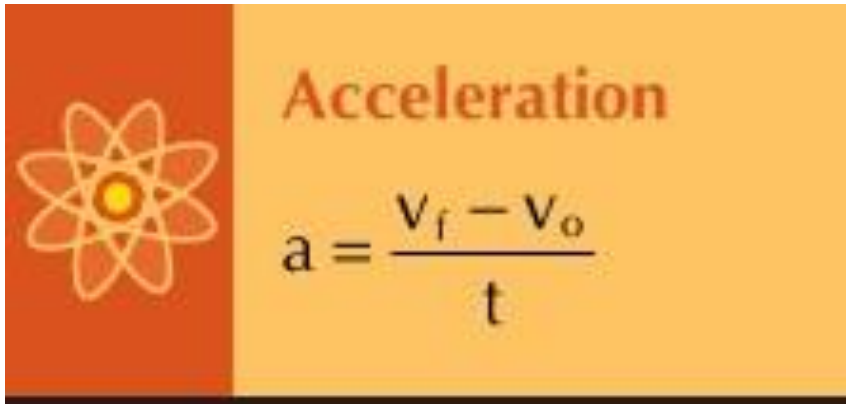
Answer: $v = \frac{d}{t}$

$$= \frac{6.69 \times 10^8 \ mi}{hr} \times \frac{1609 \ m/mi}{3600 \ s/hr}$$

$$= 2.99 \times 10^8 \text{ m/s}$$

Acceleration

The rate of change of velocity with time is acceleration. It is how "quickly or slowly" the velocity is changing. Because acceleration is velocity divided by time, the unit is meters per second squared (m/s^2). If velocity is constant, acceleration is zero. On the other hand, a constant acceleration of 2 m/s^2 means that the velocity of an object increased by 2 m/s each second. The defining equation for acceleration is given by the following:

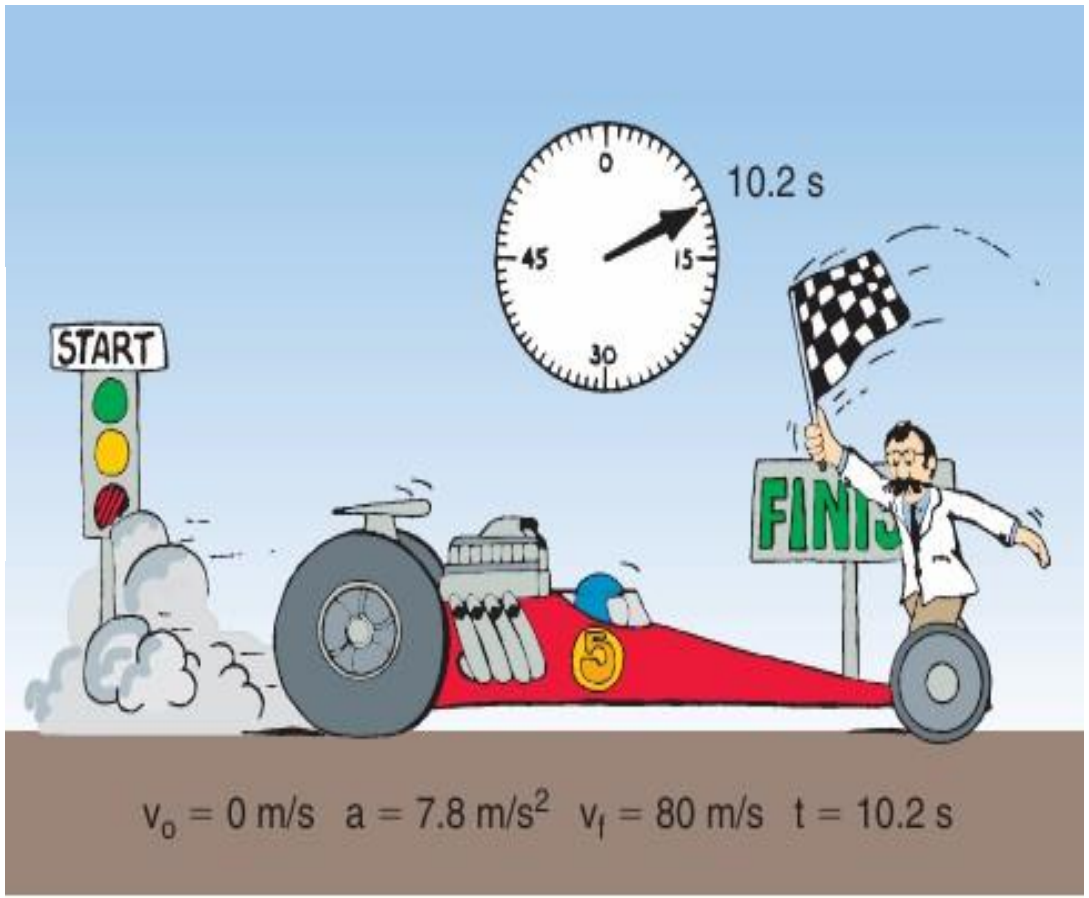


Question: What is the acceleration of the dragster?

Answer:

$$a = \frac{80\ \text{m/s} - 0\ \text{m/s}}{10.2\ \text{s}}$$

$$= 7.8\ \text{m/s}^2$$

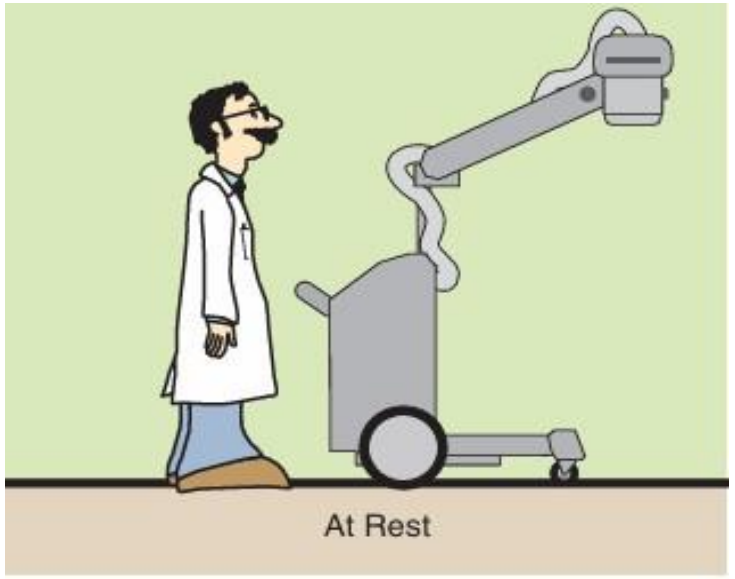


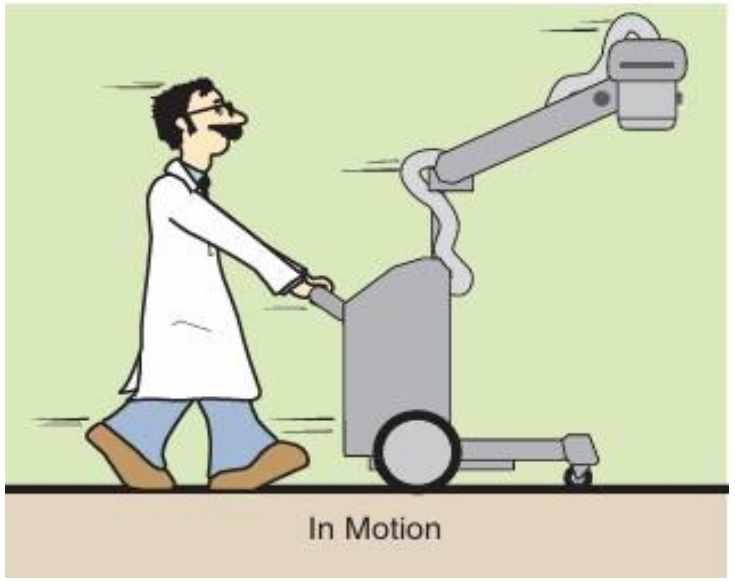
Newton's Lawsof Motion

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

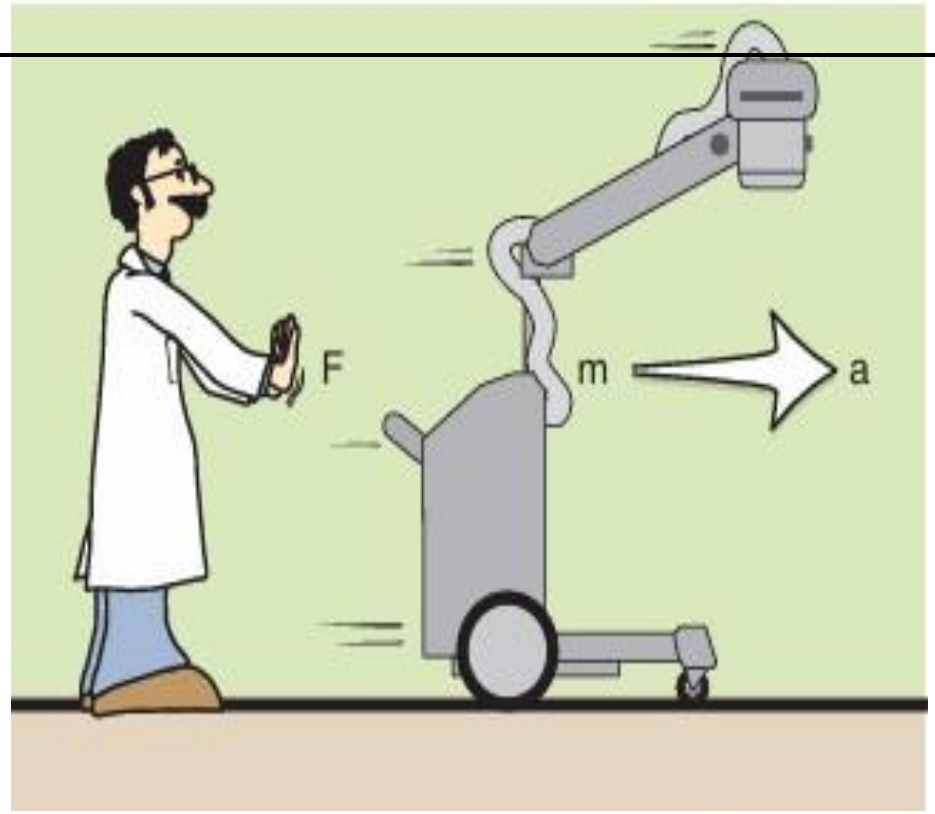
Newton's first law: Inertia—A body will remain at rest or will continue to move with constant velocity in a straight line unless acted on by an external force.

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





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/s^2.

Answer: $F = ma$

$(55\ kg)(14\ m/s^2)$

$770\ N$

Question: For a 3600-lb (1636-kg) Ford Mustang to accelerate at 15 m/s^2, what force is required?

Answer: $F = ma$

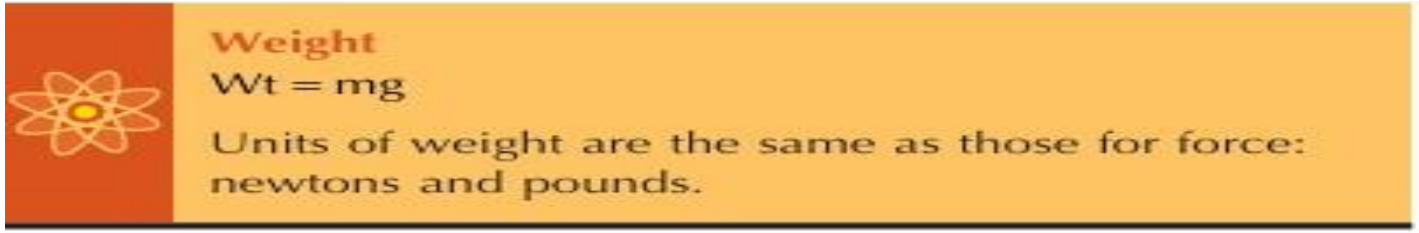
$(1636\ kg)(15\ m/s^2)$

$24,540\ N$

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

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/s^2 on Earth and 1.6 m/s^2 on the moon.



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

Answer: Earth: $g = 9.8\ m/s^2$

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

Moon: $g = 1.6\ m/s^2$

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

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.

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

1. The mass, m, of the object is $15\ \text{kg}$.
2. The velocity, v, of the object is $6\ \text{m/s North}$.
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).

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 formula for calculating velocity?**

- A) Distance × Time
- B) Distance / Time
- C) Time / Distance
- D) Distance + Time
- E) Distance - Time

2. **Which of the following is a base quantity?**

- A) Force
- B) Energy
- C) Mass
- D) Velocity
- E) Acceleration

3. What is the SI unit of length?

- A) Kilogram
- B) Meter
- C) Liter
- D) Newton
- E) Joule

4. Which equation represents the relationship between mass, density, and volume?

- A) Density = Mass + Volume
- B) Density = Mass × Volume
- C) Density = Mass / Volume
- D) Density = Volume / Mass
- E) Density = Mass - Volume

5. What does the term 'acceleration' refer to?

- A) The speed of an object
- B) The rate of change of velocity
- C) The distance traveled
- D) The mass of an object
- E) The force applied

6. Which of the following describes the concept of velocity?

- A) Distance traveled
- B) Rate of change of position
- C) Total distance
- D) Average speed
- E) Instantaneous speed

7. What is the unit of measurement for time in the SI system?

- A) Second
- B) Minute
- C) Hour
- D) Day
- E) Year

8. Which of the following is NOT a derived quantity?

- A) Velocity
- B) Acceleration
- C) Mass
- D) Force
- E) Pressure

9. What is the formula for calculating force?

- A) Mass × Acceleration
- B) Mass / Acceleration
- C) Mass + Acceleration
- D) Mass - Acceleration
- E) Acceleration / Mass

10. Which of the following describes mechanics?

- A) The study of light
- B) The study of sound
- C) The study of objects at rest and in motion
- D) The study of chemical reactions
- E) The study of electricity

11. What is the formula for calculating kinetic energy?

- A) KE = 1/2 mv^2
- B) KE = mv^2
- C) KE = mgh
- D) KE = 1/2 mgh
- E) KE = mv

12. What is the unit of force in the SI system?

- A) Joule
- B) Newton
- C) Pascal
- D) Watt
- E) Coulomb

13. Which of the following is a vector quantity?

- A) Speed
- B) Distance
- C) Mass
- D) Displacement
- E) Temperature

14. Which of the following describes acceleration?

- A) Change in velocity over time
- B) Change in distance over time
- C) Change in mass over time
- D) Change in force over time
- E) Change in energy over time

15. Which of the following is a unit of energy?

- A) Joule
- B) Newton
- C) Pascal
- D) Meter
- E) Kilogram

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) $Force^2$ × 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/s^2
2. B) 1.6 m/s^2
3. C) 0 m/s^2
4. D) 3.7 m/s^2
5. E) 4.9 m/s^2

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: