Physics Grade 9 — Chapter 3

Dynamics I · Tests from supplied DeepSeek notes PDF

Chapter Test 1 — Foundation and Understanding

Instructions:
Section A: 15 MCQs (1 mark each)
Section B: 5 Short Questions (2 marks each)
Section C: 2 Long Questions (5 marks each)
Section D: 3 Numerical Problems (3 marks each)
Total: 40 marks
Section A — Multiple Choice Questions (15 × 1 = 15 marks)
MCQ 1. Force is a:
A. Scalar quantity
B. Vector quantity
C. Base quantity
D. Derived quantity
Correct Answer: B. Vector quantity
Explanation: Force is a vector quantity because it has both magnitude and direction.
MCQ 2. The SI unit of force is the:
A. Joule
B. Newton
C. Watt
D. Pascal
Correct Answer: B. Newton
Explanation: The SI unit of force is the newton (N).
MCQ 3. Which of the following is a contact force?
A. Gravitational force
B. Electrostatic force
C. Friction
D. Magnetic force
Correct Answer: C. Friction
Explanation: Friction requires physical contact between surfaces; the others are non-contact forces.
MCQ 4. The force that keeps the positively charged protons packed in the nucleus of an atom is the:
A. Gravitational force
B. Electromagnetic force
C. Strong nuclear force
D. Weak nuclear force
Correct Answer: C. Strong nuclear force
Explanation: The strong nuclear force keeps protons and neutrons together in the nucleus.
MCQ 5. Newton's first law of motion is also called the law of:
A. Acceleration
B. Momentum
C. Inertia
D. Reaction
Correct Answer: C. Inertia
Explanation: Newton's first law describes the tendency of an object to resist changes in

motion, which is inertia.
MCQ 6. Newton's second law of motion is mathematically expressed as:

A.
B.
C.
D.
Correct Answer: B.
Explanation: Newton's second law states that .
MCQ 7. Newton's third law of motion states that:
A. Force equals mass times acceleration
B. An object at rest stays at rest
C. To every action, there is an equal and opposite reaction
D. Momentum is conserved
Correct Answer: C. To every action, there is an equal and opposite reaction
Explanation: Newton's third law states that forces always occur in equal and opposite pairs.
MCQ 8. The quantity of matter in a body is called:
A. Weight
B. Mass
C. Force
D. Momentum
Correct Answer: B. Mass
Explanation: Mass is defined as the quantity of matter in a body.
MCQ 9. The downward force with which the Earth pulls a body is called:
A. Mass
B. Weight
C. Inertia
D. Momentum
Correct Answer: B. Weight
Explanation: Weight is the gravitational force exerted by the Earth on a body.
MCQ 10. The product of mass and velocity is called:
F=m/v
F=ma
F=m+a
F=v/t
F=ma
F =net ma

A. Force
B. Acceleration
C. Momentum
D. Weight
Correct Answer: C. Momentum
Explanation: Momentum is defined as the product of mass and velocity ( ).
MCQ 11. The law of conservation of momentum states that the momentum of an isolated system:
A. Always increases
B. Always decreases
C. Remains constant
D. Becomes zero
Correct Answer: C. Remains constant
Explanation: In the absence of external forces, the total momentum of a system remains constant.

MCQ 12. Gravitational field strength is defined as:
A. Force per unit mass
B. Mass per unit force
C. Force per unit volume
D. Mass per unit volume
Correct Answer: A. Force per unit mass
Explanation: Gravitational field strength is the force per unit mass exerted by the Earth.
MCQ 13. Which of the following is a vector quantity?
A. Mass
B. Weight
C. Speed
D. Distance
Correct Answer: B. Weight
Explanation: Weight is a force and is a vector quantity; mass, speed, and distance are scalars.
=p mv

MCQ 14. The acceleration produced by a net force acting on an object is directly proportional to the:
A. Mass of the object
B. Magnitude of the net force
C. Volume of the object
D. Weight of the object
Correct Answer: B. Magnitude of the net force
Explanation: According to Newton's second law, acceleration is directly proportional to the net force.
MCQ 15. The exchange particle for the electromagnetic force is the:
A. Pion
B. Photon
C. Graviton
D. Vector boson
Correct Answer: B. Photon
Explanation: The electromagnetic force is mediated by a massless particle known as a photon.
Section B — Short Questions (5 × 2 = 10 marks)
Q1. Define force and state its SI unit.
Answer:
Force is a vector quantity that changes or tends to change the state of motion of a body. It can start or stop motion, speed it up or slow it down, or change the direction of motion. Force has both magnitude and direction. The SI unit of force is the newton (N). One newton is defined as the force that gives a mass of one kilogram an acceleration of one metre per second squared ( ). Force is a fundamental concept in dynamics and is responsible for all changes in motion.
Q2. State Newton's first law of motion and explain why it is called the law of inertia.
Answer:
Newton's first law of motion states that if the net external force acting on an object is zero, the object will maintain its state of rest or uniform motion in a straight line. This means an object at rest will remain at rest, and an object in motion will continue moving with constant velocity, unless acted upon by a net external force. It is called the law of inertia because it describes the natural tendency of an object to resist changes in its
1 N=1 kg□m/s2

state of motion. Inertia is this resistance, and mass is a measure of inertia. The greater the mass, the greater the inertia.

Q3. Differentiate between mass and weight.
Answer:
Mass is the quantity of matter in a body and is a scalar quantity measured in kilograms (kg). It is an intrinsic property of the object and does not change with location. Weight is the gravitational force exerted on a body by the Earth and is a vector quantity measured in newtons (N). Weight depends on the acceleration due to gravity ( ) and therefore changes with location. For example, an object's weight on the Moon is about one-sixth of its weight on Earth, but its mass remains the same. Mass is measured using a balance, while weight is measured using a spring scale. Mass is a measure of inertia, while weight is a measure of gravitational attraction.
Q4. State the law of conservation of momentum and give one example.
Answer:
The law of conservation of momentum states that if no net external force acts on a system of particles, the total momentum of the system remains constant. In other words, the total momentum before an interaction equals the total momentum after the interaction. For example, consider a gun firing a bullet. Before firing, the total momentum of the gun-bullet system is zero (both are at rest). After firing, the bullet moves forward with momentum , and the gun recoils backward with momentum . By conservation of momentum, , so the gun's recoil velocity is opposite to the bullet's velocity and smaller in magnitude due to the gun's larger mass.
Q5. What is momentum? Write its formula and SI unit.
Answer:
Momentum is the product of an object's mass and its velocity. It is a vector quantity that points in the same direction as the velocity. The formula for momentum is , where is the mass and is the velocity. The SI unit of momentum is kilogram-metre per second (kg·m/s), which is also equivalent to newton-second (N·s). Momentum is a measure of the "quantity of motion" of an object. A heavier object moving at the same speed as a lighter object has more momentum. Momentum is conserved in isolated systems, making it a powerful tool for analyzing collisions and explosions.
Section C — Long Questions (2 × 5 = 10 marks)
Q1. State and explain Newton's three laws of motion with examples.
W=mg
m v
bb m v
gg
m v +bb m v =gg 0
=p mv
m v
Answer:
Introduction: Newton's three laws of motion form the foundation of classical mechanics. They describe how forces affect the motion of objects.
Newton's First Law (Law of Inertia): An object at rest will remain at rest, and an object in motion will continue moving with constant velocity in a straight line, unless acted upon by a net external force. This law describes inertia—the tendency of an object to resist changes in its state of motion. Example: A book lying on a table remains at rest until someone pushes it. A passenger in a moving bus tends to fall forward when the bus stops suddenly because their body tends to remain in motion.
Newton's Second Law: The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass. The acceleration is in the direction of the net force. Mathematically, . Example: Pushing a small toy car produces a larger acceleration than pushing a heavy truck with the same force. Doubling the force doubles the acceleration; doubling the mass halves the acceleration.

Newton's Third Law: For every action, there is an equal and opposite reaction. Forces always occur in pairs, acting on different objects. Example: When you jump, you push down on the ground, and the ground pushes you up with an equal and opposite force. When a rocket expels hot gases downward, the gases push the rocket upward.
Conclusion: Newton's laws explain a wide range of motion, from everyday objects to celestial bodies. They are fundamental to understanding dynamics and are applied in engineering, sports, and space exploration.
Q2. Describe the fundamental forces of nature. Include their relative strengths and exchange particles.
Answer:
Introduction: All forces in nature arise from four fundamental forces: strong nuclear, electromagnetic, weak nuclear, and gravitational.
Strong Nuclear Force: This is the strongest of all fundamental forces. It holds protons and neutrons together in the nucleus, overcoming the electrostatic repulsion between protons. It has a very short range (about the diameter of a proton). Its exchange particles are pions. Relative strength: 1.
Electromagnetic Force: This force acts between electric charges and includes both electric and magnetic forces. It can be attractive or repulsive. It has infinite range, though its strength decreases with distance. Its exchange particle is the photon (massless). Relative strength: about . Normal force, friction, and tension are all electromagnetic in origin.
Weak Nuclear Force: This force is responsible for radioactive decay, specifically beta decay. It has the shortest range of all fundamental forces. Its exchange particles are
$F = \text{net } ma$
7.3×10^{-3}

vector bosons (, ,). Relative strength: about .
Gravitational Force: This is the weakest of all fundamental forces but acts over infinite range. It is the force of attraction between all objects with mass. It holds planets, stars, and galaxies together. Its exchange particle is theorized to be the graviton (not yet detected). Relative strength: about .
Conclusion: The four fundamental forces differ enormously in strength and range. The strong force holds the nucleus together, the electromagnetic force governs everyday interactions, the weak force causes radioactive decay, and gravity governs the cosmos. The electroweak theory unifies the electromagnetic and weak forces, a achievement to which Pakistani physicist Abdus Salam contributed.
Section D — Numerical Problems (3 × 3 = 9 marks)
Q1. A force of 20 N acts on a mass of 4 kg. Calculate the acceleration produced.
Solution:
Given:
Force
Mass
Required:
Acceleration
Formula:
Substitution:
Final Answer:
Verification: . Correct.
Q2. A body of mass 5 kg is moving with a velocity of 10 m/s. Calculate its momentum.
Solution:
Given:
Mass
Velocity

W+W−Z0 10−5
6×10−39
F=20 N
m=4 kg
a
a=
m
F
a= =420 5 m/s2
a=5 m/s2
F=ma=4×5=20 N
m=5 kg
v=10 m/s
Required:
Momentum
Formula:
Substitution:
Final Answer:
Verification: Units: . Correct.
Q3. A gun of mass 4 kg fires a bullet of mass 20 g with a velocity of 400 m/s. Calculate the recoil velocity of the gun.
Solution:
Given:
Mass of gun
Mass of bullet
Velocity of bullet
Required:
Recoil velocity of gun
Formula:
By conservation of momentum:
Substitution:
Final Answer:
The negative sign indicates that the gun recoils in the opposite direction to the bullet.
Verification: Total momentum before firing = 0. Total momentum after =
. Correct.
p
p=mv
p=5×10=50 kg□m/s
p=50 kg□m/s
kg□m/s
m =g 4 kg
m =b 20 g=0.02 kg
v =b 400 m/s
v
g
m v +gg m v =bb 0
v =g −
m
g
m v
bb
v =g − =40.02×400 − =48 −2 m/s

$v = g - 2$ m/s

$4(-2) +$

$0.02(400) = -8 + 8 = 0$

Answer Key and Detailed Solutions — Test 1

MCQ Answers

1. B
2. B
3. C
4. C
5. C
6. B
7. C
8. B
9. B
10. C
11. C
12. A
13. B
14. B
15. B

Short Answers

(Provided above in Section B.)

Long Answers

(Provided above in Section C.)

Numerical Solutions

(Provided above in Section D.)

Chapter Test 2 — Understanding and Application

Board: FBISE
Class: 9
Subject: Physics
Section A — Multiple Choice Questions (15 × 1 = 15 marks)
MCQ 1. If a net force of 10 N acts on a mass of 2 kg, the acceleration is:
A.
B.
C.
D.
Correct Answer: A.
Explanation: Using .
5 m/s2
10 m/s2
20 m/s2
2 m/s2
5 m/s2
a=F/m=10/2=5 m/s2

MCQ 2. The same engine is installed in a bus (mass 12,000 kg) and a car (mass 1,200 kg), applying a force of 3000 N. The acceleration of the bus is:
A.
B.
C.
D.
Correct Answer: A.
Explanation: .
MCQ 3. For the same engine in MCQ 2, the acceleration of the car is:
A.
B.
C.
D.
Correct Answer: B.
Explanation: .
MCQ 4. A force of 5 N is applied to a body weighing 10 N. Its acceleration is: (Take)
A.
B.
C.
D.
Correct Answer: C.
Explanation: Mass = weight/g = . Acceleration = .
MCQ 5. A book of mass 5 kg is placed on a table. The magnitude of the net force acting on the book is:
A.
B.
C.
D.
Correct Answer: D.
0.25 m/s2
2.5 m/s2
0.025 m/s2
25 m/s2
0.25 m/s2

a=F/m=3000/12000=0.25 m/s2
0.25 m/s2
2.5 m/s2
0.025 m/s2
25 m/s2
2.5 m/s2
a=F/m=3000/1200=2.5 m/s2
g=
10 m/s2
0.5 m/s2
2 m/s2
5 m/s2
50 m/s2
5 m/s2
10/10=1 kg F/m=5/1=5 m/s2
50 N
5 N
25 N
0 N
0 N

Explanation: The book is at rest; the normal force balances the weight, so the net force is zero.

MCQ 6. A force acts on a body for 2 seconds and produces a change in momentum of . The force is:

A.
B.
C.
D.

Correct Answer: C.

Explanation: Force = change in momentum / time = .

MCQ 7. A golfer hits a ball of mass 45 g, giving it a speed of . The momentum imparted is:

A.
B.
C.
D.

Correct Answer: A.

Explanation: .

MCQ 8. A force of to the right and a force of to the left act on an object. The net force is:

A. to the right
B. to the right
C. to the left
D. to the left

Correct Answer: B. to the right

Explanation: The forces are in opposite directions; net force = to the right.

MCQ 9. When a hanging carpet is beaten with a stick, dust flies off because:

A. The carpet moves and the dust stays due to inertia
B. The dust is attracted to the stick
50 kg□m/s
100 N
50 N
25 N
2 N

25 N
50/2=25 N
80 m/s
3.6 kg□m/s
36 kg□m/s
0.36 kg□m/s
360 kg□m/s
3.6 kg□m/s
p=mv=0.045×80=3.6 kg□m/s
5 N 3 N
8 N
2 N
2 N
8 N
2 N
5−3=2 N

C. The carpet repels the dust
D. The dust has no mass
Correct Answer: A. The carpet moves and the dust stays due to inertia
Explanation: When the carpet is beaten, it moves, but the dust particles tend to remain at rest due to inertia, causing them to separate.
MCQ 10. The mass of a body is 8 kg. Its weight on Earth is: (Take)
A.
B.
C.
D.
Correct Answer: A.
Explanation: .
MCQ 11. The mass of a body is 8 kg. Its weight on the Moon is: (Take)
A.
B.
C.
D.
Correct Answer: B.
Explanation: .
MCQ 12. A box weighs 400 N on Earth and 150 N on an unknown planet. The gravitational field strength on that planet is: (Take)
A.
B.
C.
D.
Correct Answer: A.
Explanation: .
MCQ 13. A car of mass 1200 kg moving at is stopped in 5 s. The force required is:
g=9.8 m/s2
78.4 N
8 N
9.8 N
80 N
78.4 N
W=mg=8×9.8=78.4 N
g =m 1.625 m/s2
78.4 N

13 N
8 N
1.625 N
13 N
W =m m×g =m 8×1.625=13 N
g =e 9.8 N/kg
3.675 N/kg
36.75 N/kg
0.3675 N/kg
367.5 N/kg
3.675 N/kg
g =N (W /W)×N E g =E (150/400)×9.8=3.675 N/kg
8 m/s

A.
B.
C.
D.
Correct Answer: A.
Explanation: .
MCQ 14. The impulse is defined as the product of:
A. Mass and velocity
B. Force and time
C. Force and distance
D. Mass and acceleration
Correct Answer: B. Force and time
Explanation: Impulse is the product of force and the time interval over which it acts (
).
MCQ 15. A rocket accelerates in space because:
A. It pushes against the air
B. The hot gases it expels have momentum, and the rocket gains equal and opposite momentum
C. Gravity pulls it forward
D. It has no mass
Correct Answer: B. The hot gases it expels have momentum, and the rocket gains equal and opposite momentum
Explanation: Rockets accelerate in space due to conservation of momentum; the expelled gases have momentum, and the rocket gains equal and opposite momentum.
Section B — Short Questions (5 × 2 = 10 marks)
Q1. Explain why a passenger in a moving bus tends to fall forward when the bus stops suddenly.
Answer:
This is due to Newton's first law of motion, also called the law of inertia. When the bus is moving, the passenger is also moving with the same velocity. When the bus stops suddenly, the lower part of the passenger's body (in contact with the seat) slows down with the bus, but the upper part of the body tends to remain in motion due to inertia. This
−1920 N
1920 N
−960 N
960 N
−1920 N
F=(mv −f mv)/t=i (0−1200×8)/5=−1920 N
J=F×Δt

causes the passenger to lurch forward. The same principle explains why you feel pushed backward when the bus starts moving: the lower body moves with the bus, but the upper body tends to remain at rest. This demonstrates the tendency of objects to resist changes in their state of motion.

Q2. State Newton's third law of motion and explain why action and reaction forces do not cancel each other.

Answer:

Newton's third law states that for every action, there is an equal and opposite reaction. This means that whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first. Action and reaction forces do not cancel each other because they act on different objects. For example, when you push a wall, you exert a force on the wall, and the wall exerts an equal and opposite force on you. The force on the wall does not cancel the force on you because they are acting on different bodies. Since they act on different objects, they cannot balance each other, and motion can result.

Q3. Differentiate between contact and non-contact forces with examples.

Answer:

Contact forces are forces that act between objects in physical contact with each other. They require direct touching. Examples include normal force (a book on a table), friction (rubbing hands), tension (a string pulling an object), thrust (a rocket engine), and elastic force (a stretched spring). Non-contact forces are forces that act at a distance without any physical contact between the objects. They are also called action-at-a-distance forces. Examples include gravitational force (the Earth pulling an apple), electrostatic force (attraction between charged balloons), and magnetic force (a magnet attracting iron filings). Contact forces require physical interaction, while non-contact forces act through fields.

Q4. Explain the concept of gravitational field strength and its relationship with weight.

Answer:

Gravitational field strength () is defined as the gravitational force per unit mass exerted on an object in a gravitational field. It is a vector quantity with the SI unit of newton per kilogram (N/kg). At the Earth's surface, its value is approximately directed downward. The weight of an object () is related to its mass () and gravitational field strength by the equation . This means that weight is the gravitational force acting on an object. The gravitational field strength is numerically equal to the acceleration due to gravity ( ). On different planets, the gravitational field strength varies, so an object's weight changes while its mass remains constant.

g

9.8 N/kg

W m

W=mg

g=9.8 m/s2

Q5. What is momentum? Explain how the concept of impulse relates to a change in momentum.

Answer:

Momentum () is the product of an object's mass and velocity ( ). It is a vector quantity that points in the direction of velocity. Impulse is defined as the product of force and the time interval over which it acts ( ). According to Newton's second law, the force acting on an object is equal to the rate of change of its momentum: . Rearranging this gives , which means impulse equals the change in momentum. This relationship is useful for analyzing collisions, where a large force acting over a short time (large impulse) produces a change in momentum. For example, a bat hitting a ball applies a force over a short time, changing the ball's momentum.

Section C — Long Questions (2 × 5 = 10 marks)

Q1. Explain the concept of net force. How is it calculated for forces acting in the same direction and in opposite directions? Provide examples.
Answer:
Introduction: Net force (or resultant force) is the single force that represents the vector sum of all the individual forces acting on an object. It determines the object's acceleration.
Calculation for Forces in the Same Direction (Like Parallel Forces): When forces act in the same direction, their magnitudes add up. The net force is in the same direction as the individual forces. For example, if two people push a car with forces of 100 N and 150 N in the same direction, the net force is in the direction of the push.
Calculation for Forces in Opposite Directions (Unlike Parallel Forces): When forces act in opposite directions, the smaller magnitude is subtracted from the larger magnitude. The net force is in the direction of the larger force. For example, in a tug of war, if team A pulls with 500 N to the left and team B pulls with 600 N to the right, the net force is to the right (direction of the larger force).
Balanced vs. Unbalanced Forces: If the net force is zero, the forces are balanced, and the object's motion does not change (it remains at rest or moves with constant velocity). If the net force is not zero, the forces are unbalanced, and the object accelerates in the direction of the net force.
Conclusion: Net force is the combined effect of all forces acting on an object. It determines whether the object accelerates and in which direction. Understanding net force is essential for applying Newton's second law of motion.
p =p mv
J=F×Δt
F=
Δp/Δt F×Δt=Δp
100+150=250 N
600−500=100 N

Q2. State Newton's second law of motion. Derive the relationship from the rate of change of momentum.
Answer:
Introduction: Newton's second law of motion relates the net force acting on an object to its acceleration. It is a fundamental principle of dynamics.
Statement: The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object.
Derivation from Momentum: The momentum of an object is . According to Newton's second law, the net force is equal to the rate of change of momentum:
For a constant mass, the change in momentum is:
Therefore:
Since acceleration , we get:
Example: If a force of 10 N acts on a mass of 2 kg, the acceleration is . If the mass is doubled to 4 kg, the acceleration becomes , showing the inverse relationship.
Conclusion: Newton's second law, expressed as , quantifies the relationship between force, mass, and acceleration. It is the most widely used law in dynamics and allows us to calculate the motion of objects under the action of forces.
Section D — Numerical Problems (3 × 3 = 9 marks)
Q1. A car of mass 1500 kg accelerates from rest to 20 m/s in 8 s. Calculate the net force acting on the car.
Solution:
Given:

Mass
Initial velocity
Final velocity
Time
$F=ma$
$=p\ mv$
$F=net$

Δt
Δp
$\Delta p=m(v-f\ v)i$
$F=net$

Δt
$m(v-v)f\ i$
$a=(v-f\ v)/\Delta ti$
$F=net\ ma$
$a=10/2=$
$5\ m/s2\ 10/4=2.5\ m/s2$
$F=ma$
$m=1500\ kg$
$u=0\ m/s$
$v=20\ m/s$
$t=8\ s$

Required:
Net force
Formula:
Substitution for acceleration:
Substitution for force:
Final Answer:
Verification: . Correct.

Q2. A bullet of mass 10 g is fired from a gun of mass 2 kg. The bullet leaves the gun with a velocity of 300 m/s. Calculate the recoil velocity of the gun.

Solution:
Given:
Mass of bullet
Mass of gun
Velocity of bullet
Required:
Recoil velocity of gun
Formula:
By conservation of momentum:
Substitution:
Final Answer:

F
$a=$
t
$v-u$
$F=ma$
$a==8$
$20-0\ 2.5\ m/s2$
$F=1500\times 2.5=3750\ N$
$F=3750\ N$

a=F/m=3750/1500=2.5 m/s2
m =b 10 g=0.01 kg
m =g 2 kg
v =b 300 m/s
v
g
m v +gg m v =bb 0
v =g −
m
g
m v
bb
v =g − =2
0.01×300 − =2
3 −1.5 m/s

The negative sign indicates that the gun recoils in the opposite direction to the bullet.
Verification: Total momentum after firing = .
Correct.
Q3. A force of 50 N acts on a body for 4 s. Calculate the impulse and the change in momentum.
Solution:
Given:
Force
Time
Required:
Impulse and change in momentum
Formula:
Substitution:
Final Answer:
Verification: . Correct.

Answer Key and Detailed Solutions — Test 2
MCQ Answers
1. A
2. A
3. B
4. C
v =g −1.5 m/s
2(−1.5)+0.01(300)=−3+3=0
F=50 N
t=4 s
J Δp
J=F×t
J=Δp
J=50×4=200 N□s
Δp=200 kg□m/s
J=200 N□s
Δp=200 kg□m/s
1 N□s=1 kg□m/s

5. D
6. C
7. A

8. B
9. A
10. A
11. B
12. A
13. A
14. B
15. B

Short Answers

(Provided above in Section B.)

Long Answers

(Provided above in Section C.)

Numerical Solutions

(Provided above in Section D.)

Chapter Test 3 — Application, Reasoning, and Exam Preparation

Board: FBISE
Class: 9
Subject: Physics
Section A — Multiple Choice Questions (15 × 1 = 15 marks)
MCQ 1. A boy is holding a book of mass 2 kg. The force he applies on the book is: (Take
)
A.
B.
C.
D.
Correct Answer: A.
Explanation: The force applied must balance the weight of the book:
.
MCQ 2. For the boy in MCQ 1, if he moves the book up with an acceleration of ,
the total force he applies is:
A.
B.
C.
D.
Correct Answer: B.
Explanation: Total force = weight + ma = .
MCQ 3. A girl of mass 30 kg is running with a velocity of . Her momentum is:
A.
B.
C.
D.
g=9.8 m/s2
19.6 N
2 N
9.8 N
0 N
19.6 N
F=mg=2×
9.8=19.6 N
3 m/s2
19.6 N
25.6 N
6 N
3 N
25.6 N
19.6+2×3=25.6 N
4 m/s
120 kg□m/s
34 kg□m/s
7.5 kg□m/s
0 kg□m/s

Correct Answer: A.
Explanation: .
MCQ 4. A 2 kg steel ball moving at hits a bulk of sand and comes to rest in 0.2 s.
The force applied by the sand on the ball is:
A.
B.
C.

D.
Correct Answer: A.
Explanation: .
MCQ 5. A 100 g bullet is fired from a 5 kg gun with a muzzle velocity of . The recoil velocity of the gun is:
A.
B.
C.
D.
Correct Answer: A.
Explanation: By conservation of momentum: .
MCQ 6. A robotic car of 15 kg is moving at . Brakes apply a constant force of 50 N to stop it. The time taken to stop is:
A.
B.
C.
D.
Correct Answer: A.
Explanation: Time = change in momentum / force = .
MCQ 7. A force of is applied to a body of mass for . The change in velocity is:
A.
B.
120 kg□m/s
p=mv=30×4=120 kg□m/s
15 m/s
−150 N
150 N
−30 N
30 N
−150 N
F=(mv −f mv)/t=i (0−2×15)/0.2=−150 N
20 m/s
−0.4 m/s
0.4 m/s
−4 m/s
4 m/s
−0.4 m/s
v =g −(0.1×20)/5=−0.4 m/s
25 m/s
7.5 s
0.75 s
75 s
1.5 s
7.5 s
(15×25)/50=7.5 s
10 N 2 kg 3 s
15 m/s
5 m/s
C.
D.
Correct Answer: A.
Explanation: . Change in velocity =
.
MCQ 8. Two objects of masses and are moving with velocities and . If they collide and stick together, the final velocity is:
A.
B.
C.

D.
Correct Answer: A.
Explanation: By conservation of momentum, the total initial momentum equals the total final momentum, giving this expression for the final velocity.
MCQ 9. A rocket of mass 1000 kg expels 100 kg of gas at . The velocity gained by the rocket is:
A.
B.
C.
D.
Correct Answer: A.
Explanation: By conservation of momentum: .
MCQ 10. A person is standing in a bus. When the bus starts moving, the person tends to fall backward because:
A. The bus pushes the person backward
B. The lower part of the body moves with the bus, but the upper part tends to remain at rest due to inertia
C. Gravity pulls the person backward
D. The person is pushed by the air
Correct Answer: B. The lower part of the body moves with the bus, but the upper part tends to remain at rest due to inertia
6 m/s
30 m/s
15 m/s
a=F/m=10/2=5 m/s2 a×t=5×3=
15 m/s
m
1 m
2 v
1 v
2
m +m
1 2
m v +m v
1 1 2 2
m +m
1 2
m v −m v
1 1 2 2
m2
m v
1 1
v +1 v
2
m +m
1 2
m v +m v
1 1 2 2
500 m/s
50 m/s
5 m/s

500 m/s
0.5 m/s
50 m/s
v =r (100×500)/1000=50 m/s

Explanation: Due to inertia, the upper body tends to remain at rest while the lower body moves with the bus, causing the person to feel pushed backward.

MCQ 11. A ball of mass 0.5 kg is dropped from a height of 10 m. The force acting on the ball during the fall is: (Take)

A.
B.
C.
D.

Correct Answer: A.

Explanation: The force acting on the ball is its weight: .

MCQ 12. In a tug of war, team A pulls with 500 N and team B pulls with 600 N. The net force on the rope is:

A. towards team A
B. towards team B
C. towards team B
D.

Correct Answer: B. towards team B

Explanation: The net force is the difference between the forces: in the direction of the larger force (team B).

MCQ 13. A body of mass 5 kg is moving with a velocity of . A force of 50 N is applied in the direction of motion for 2 s. The final velocity is:

A.
B.
C.
D.

Correct Answer: B.

Explanation: . .

MCQ 14. A body of mass 4 kg is at rest. A force of 8 N is applied for 3 s. The distance traveled is:

g=9.8 m/s2
4.9 N
0.5 N
9.8 N
5 N
4.9 N
W=mg=0.5×9.8=4.9 N
100 N
100 N
1100 N
0 N
100 N
600−500=100 N
10 m/s
20 m/s
30 m/s
10 m/s
40 m/s
30 m/s
a=F/m=50/5=10 m/s2v =f v +i at=10+10×2=30 m/s

A.
B.

C.
D.
Correct Answer: B.
Explanation: . .
MCQ 15. A body of mass 2 kg is moving at . It collides with a stationary body of mass 4 kg and sticks to it. The final velocity of the combined mass is:
A.
B.
C.
D.
Correct Answer: A.
Explanation: By conservation of momentum:
.
Section B — Short Questions (5 × 2 = 10 marks)
Q1. Explain why a rocket can accelerate in space where there is no air to push against.
Answer:
A rocket accelerates in space due to the law of conservation of momentum, not because it pushes against air. When the rocket's engines burn fuel, they expel hot gases at high speed in the backward direction. These gases have momentum. According to Newton's third law and the conservation of momentum, the rocket gains an equal and opposite momentum in the forward direction. Since there is no external force (like air resistance) in space, the total momentum of the rocket-gas system remains constant. The expulsion of gases with large backward momentum results in the rocket gaining large forward momentum, causing it to accelerate. This is why rockets can travel in the vacuum of space.
Q2. A cricketer catches a ball by moving his hands backward. Explain why this reduces the force on his hands.
Answer:
When a cricketer catches a fast-moving ball, the ball has a certain momentum. To stop the ball, its momentum must be reduced to zero. According to Newton's second law, the force required to change momentum is . If the hands are kept stationary,
the time interval ( ) for stopping the ball is very short, so the force is very large, which
18 m
9 m
36 m
12 m
9 m
a=F/m=8/4=2 m/s2s=ut+ at =21 2 0+ ×21 2×3 =2 9 m
6 m/s
2 m/s
3 m/s
6 m/s
1 m/s
2 m/s
2×6+4×0=(2+4)v □f 12=
6v □f v =f 2 m/s
F=Δp/Δt
Δt
can cause injury. By moving his hands backward, the cricketer increases the time interval over which the ball's momentum changes. Since the change in momentum is the same, a longer time interval results in a smaller force on his hands. This is an application of the impulse-momentum relationship.

Q3. Explain why it is dangerous to jump out of a moving vehicle even if it is moving slowly.

Answer:

When you jump out of a moving vehicle, you are initially moving with the same velocity as the vehicle. Upon landing, your feet come to rest (due to friction with the ground), but your upper body continues to move forward due to inertia. This can cause you to fall forward and sustain injuries. Additionally, the ground exerts a large force on your body to bring it to rest. If you jump from a height, the time interval for stopping is short, resulting in a large force. It is safer to remain in the vehicle, where the seatbelt and other safety features increase the stopping time and reduce the force on your body. This illustrates Newton's first law (inertia) and the impulse-momentum relationship.

Q4. A balloon is filled with air and released. It moves forward as the air escapes backward. Explain this using Newton's third law and conservation of momentum.

Answer:

When the balloon is released, the stretched rubber exerts a force on the air inside, expelling it backward. According to Newton's third law, the air exerts an equal and opposite force on the balloon, pushing it forward. Alternatively, this can be explained using conservation of momentum. Initially, the balloon and air are at rest, so the total momentum is zero. When the air is expelled backward with some momentum, the balloon must gain an equal forward momentum to keep the total momentum zero. This is why the balloon moves forward. The same principle applies to rockets, which expel gases backward to move forward.

Q5. Explain the difference between the mass and weight of an object. How does the weight of an object change on the Moon?

Answer:

Mass is the quantity of matter in an object and is a scalar quantity measured in kilograms. It is an intrinsic property and remains constant regardless of location. Weight is the gravitational force acting on an object and is a vector quantity measured in newtons. It depends on the acceleration due to gravity at the object's location ( ). On the Moon, the acceleration due to gravity is about one-sixth of that on Earth (compared to). Therefore, an object's weight on the Moon is about one-sixth of its weight on Earth. However, its mass remains the same. For example, an object with a mass of 6 kg weighs about 58.8 N on Earth but only about 9.75 N on the Moon.

$W = mg$

$g_m \approx 1.625\ m/s^2$ $9.8\ m/s^2$

Section C — Long Questions (2 × 5 = 10 marks)

Q1. State the law of conservation of momentum. Explain how it applies to (a) the recoil of a gun and (b) the motion of a rocket.

Answer:

Introduction: The law of conservation of momentum states that if no net external force acts on a system, the total momentum of the system remains constant. This means the total momentum before an interaction equals the total momentum after the interaction.

Recoil of a Gun: Before firing, the gun and bullet are at rest, so the total momentum of the system is zero. When the gun is fired, the bullet moves forward with momentum , and the gun recoils backward with momentum . By conservation of momentum:

The negative sign indicates that the gun recoils in the opposite direction to the bullet. Because the gun is much more massive than the bullet, its recoil velocity is much smaller.

Motion of a Rocket: A rocket carries fuel that is burned and expelled as hot gases.

Initially, the rocket and fuel are at rest, so the total momentum is zero. When the gases are expelled backward with high momentum, the rocket gains an equal and opposite forward momentum. By conservation of momentum:
This allows the rocket to accelerate in space, where there is no air to push against. The continuous expulsion of gases results in continuous acceleration.
Conclusion: The law of conservation of momentum explains both gun recoil and rocket propulsion. In both cases, the total momentum of the system remains zero, and the motion of one part is balanced by the opposite motion of the other.
Q2. Explain the concept of impulse. How does it relate to Newton's second law and the change in momentum? Provide a practical example.
m v
bb m v
gg
m v +bb m v =gg 0
v =g −
m
g
m v
bb
m v +rr m v =gg 0
v =r −
m
r
m v
gg
Answer:
Introduction: Impulse is defined as the product of the force exerted on an object and the time interval over which the force acts. It is a vector quantity with the SI unit of newton-second (N·s).
Relationship to Newton's Second Law: Newton's second law states that the net force on an object equals the rate of change of its momentum:
Rearranging this equation gives:
The left side is the impulse, and the right side is the change in momentum. Therefore, impulse equals the change in momentum. This relationship is known as the impulse-momentum theorem.
Practical Example: When a cricketer catches a ball, the ball has momentum. To stop it, the cricketer must apply an impulse to change its momentum to zero. If he keeps his hands stationary, the time interval is short, so the force is large (and may hurt). By moving his hands backward as he catches the ball, he increases the time interval. Since the impulse (change in momentum) is the same, a longer time interval results in a smaller force on his hands. This is why coaches teach players to "give" with the catch.
Another Example: Airbags in cars work on the same principle. During a collision, the airbag increases the time over which the passenger's momentum changes, reducing the force on the passenger and reducing injury.
Conclusion: Impulse is a useful concept for analyzing situations where a force acts over a short time. It connects force and time to the change in momentum, and it explains why increasing the time of impact reduces the force.
Section D — Numerical Problems (3 × 3 = 9 marks)
Q1. A car of mass 800 kg is moving at 20 m/s. It collides with a stationary car of mass 1200 kg. After the collision, the two cars stick together. Calculate their common velocity after the collision.
Solution:

Given:
Mass of car 1
Velocity of car 1
Mass of car 2
Velocity of car 2
F=
Δt
Δp
F×Δt=Δp
m =1 800 kg
v =1 20 m/s
m =2 1200 kg
v =2 0 m/s
Required:
Common velocity after collision
Formula:
By conservation of momentum:
Substitution:
Calculation:
Final Answer:
Verification: Initial momentum = . Final momentum =
. Correct.
Q2. A force of 100 N acts on a body of mass 10 kg for 5 s. Calculate the impulse and the change in velocity.
Solution:
Given:
Force
Mass
Time
Required:
Impulse and change in velocity
Formula:
Substitution for impulse:
v
f
m v +1 1 m v =2 2 (m +1 m)v
2 f
800×20+1200×0=(800+1200)v
f
16000=2000v
f
v =f
=2000
16000 8 m/s
v =f 8 m/s
800×20=16000 kg□m/s
2000×8=16000 kg□m/s
F=100 N
m=10 kg
t=5 s
J Δv
J=F×t

$J=\Delta p=m\Delta v$

$\Delta v=$

m

J

$J=100\times5=500\ N\square s$

Substitution for change in velocity:

Final Answer:

Verification: . .

Correct.

Q3. A rocket of mass 2000 kg is moving at 100 m/s. It expels 200 kg of gas at a velocity of 400 m/s relative to the rocket. Calculate the final velocity of the rocket.

Solution:

Given:

Mass of rocket

Initial velocity of rocket

Mass of gas expelled

Velocity of gas relative to rocket (backward)

Required:

Final velocity of rocket

Formula:

By conservation of momentum:

Wait, this is more complex. Let's use the simpler approach: the initial momentum of the system (rocket + gas) equals the final momentum.

Initial momentum =

.

Final momentum = (where is the velocity of the gas in the ground frame, assuming gas is expelled backward).

Wait, let's simplify: the gas is expelled backward with velocity relative to the rocket.

So the velocity of the gas in the ground frame is .

By conservation of momentum:

$\Delta v=$ $=10500$ 50 m/s

$J=500\ N\square s$

$\Delta v=50$ m/s

$a=F/m=100/10=10\ m/s2\ \Delta v=a\times t=10\times5=50$ m/s

$m=r$ 2000 kg

$v=i$ 100 m/s

$m=g$ 200 kg

$v=g$ 400 m/s

v

f

$(m+r\ m)v=g\ i\ m\ v+rf\ m\ (v-g\ f\ v)g$

$(m+r\ m)v=g\ i\ (2000+200)\times100=2200\times100=$

220,000 $kg\square m/s$

$m\ v+rf\ m\ (v-g\ f\ v)g\ v-f\ v$

g

v

g

$v-f\ v$

g

$(m+r\ m)v=g\ i\ m\ v+rf\ m\ (v-g\ f\ v)g$

$2200\times100=2000v+f\ 200(v-f\ 400)$

$220,000=2000v+f\ 200v-f\ 80,000$

220,000+80,000=2200v
f

Final Answer:
Verification: The rocket's velocity increases from 100 m/s to about 136.36 m/s, which is consistent with the expulsion of gas backward.

Answer Key and Detailed Solutions — Test 3
MCQ Answers
1. A
2. B
3. A
4. A
5. A
6. A
7. A
8. A
9. A
10. B
11. A
12. B
13. B
14. B
15. A
Short Answers
(Provided above in Section B.)
Long Answers
(Provided above in Section C.)
Numerical Solutions
(Provided above in Section D.)
300,000=2200v
f
v =f
≈2200300,000 136.36 m/s
v ≈f 136.36 m/s