Physics Grade 9 — Chapter 4

Dynamics II · 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. The turning effect produced in a body about a fixed point due to an applied force is called:
A. Force
B. Momentum
C. Torque
D. Inertia
Correct Answer: C. Torque
Explanation: The turning effect of a force is called the moment of force or torque.
MCQ 2. The formula for torque is:
A.
B.
C.
D.
Correct Answer: B.
Explanation: Torque is equal to the magnitude of the force multiplied by the moment arm, .
MCQ 3. The perpendicular distance from the axis of rotation to the line of action of the force is called the:
A. Force
B. Moment arm
C. Torque
D. Line of action
Correct Answer: B. Moment arm
τ=F/d
τ=F×d
τ=F+d
τ=d/F
τ=F×d
τ=F×d

Explanation: The perpendicular distance 'd' is termed the moment arm.
MCQ 4. The SI unit of torque is:
A. Newton (N)
B. Joule (J)
C. Newton-metre (N·m)
D. Watt (W)
Correct Answer: C. Newton-metre (N·m)
Explanation: The SI unit of torque is N·m.
MCQ 5. Torque is a:
A. Scalar quantity

B. Vector quantity
C. Base quantity
D. Derived quantity
Correct Answer: B. Vector quantity
Explanation: Torque is a vector quantity; it has both magnitude and direction.
MCQ 6. By convention, anticlockwise torque is taken as:
A. Positive
B. Negative
C. Zero
D. Infinite
Correct Answer: A. Positive
Explanation: By convention, anticlockwise moment is taken as positive.
MCQ 7. By convention, clockwise torque is taken as:
A. Positive
B. Negative
C. Zero
D. Infinite
Correct Answer: B. Negative
Explanation: By convention, clockwise moment is taken as negative.

MCQ 8. The point about which mass is equally distributed in a body is called the:
A. Center of gravity
B. Center of mass
C. Pivot point
D. Fulcrum
Correct Answer: B. Center of mass
Explanation: The center of mass is the point about which mass is equally distributed.
MCQ 9. The point where the whole weight of the body appears to act is called the:
A. Center of mass
B. Center of gravity
C. Pivot point
D. Fulcrum
Correct Answer: B. Center of gravity
Explanation: The center of gravity is the point where the whole weight of the body appears to act.
MCQ 10. For small objects, the center of mass and center of gravity are:
A. Different
B. The same
C. Always outside the object
D. Always zero
Correct Answer: B. The same
Explanation: For small objects, the center of mass and center of gravity are at the same point.
MCQ 11. The state in which all forces and torques acting on an object are balanced is called:
A. Motion
B. Equilibrium
C. Acceleration
D. Inertia
Correct Answer: B. Equilibrium

Explanation: Equilibrium is the state in which all forces and torques are balanced.
MCQ 12. The first condition of equilibrium states that the:
A. Net torque is zero
B. Net force is zero

C. Net momentum is zero
D. Net acceleration is zero
Correct Answer: B. Net force is zero
Explanation: The first condition of equilibrium is that the vector sum of all forces is zero.
MCQ 13. The second condition of equilibrium is also called the:
A. Principle of moments
B. Principle of inertia
C. Principle of force
D. Principle of motion
Correct Answer: A. Principle of moments
Explanation: The second condition of equilibrium is also called the principle of moments.
MCQ 14. The force that opposes relative motion between surfaces in contact is called:
A. Gravity
B. Friction
C. Tension
D. Normal force
Correct Answer: B. Friction
Explanation: Friction is the resistance to relative motion between surfaces in contact.
MCQ 15. The force that keeps an object moving in a circular path is called:
A. Centrifugal force
B. Centripetal force
C. Gravitational force
D. Frictional force
Correct Answer: B. Centripetal force
Explanation: Centripetal force pulls an object into a circular path.

Section B — Short Questions (5 × 2 = 10 marks)

Q1. Define torque and explain how it depends on the force and the moment arm.

Answer:

Torque (or moment of force) is the turning effect produced in a body about a fixed point due to an applied force. It is a vector quantity with the SI unit of newton-metre (N·m). Torque depends on two factors: the magnitude of the applied force and the moment arm. The moment arm is the perpendicular distance from the axis of rotation to the line of action of the force. The relationship is given by . Increasing either the force or the moment arm increases the torque. This is why it is easier to open a door by pushing near the handle (large moment arm) than near the hinges (small moment arm).

Q2. What is the difference between the center of mass and the center of gravity?

Answer:

The center of mass (CM) is the point at which the entire mass of an object can be considered to be concentrated. It is the average position of the mass distribution. The center of gravity (CG) is the point at which the entire weight of an object can be considered to act. For small objects, the CM and CG are at the same point because the acceleration due to gravity is uniform. However, for very tall objects (like mountains or tall buildings), the value of changes slightly with altitude, so the CM and CG may differ slightly. In most everyday situations, they are treated as the same point.

Q3. State the two conditions of equilibrium.

Answer:

For an object to be in complete equilibrium, two conditions must be satisfied. The first condition is that the net force acting on the object must be zero: . This ensures translational equilibrium, meaning the object will either remain at rest or move with constant velocity. The second condition is that the net torque acting on the object must be zero: . This ensures rotational equilibrium, meaning the object will either not rotate or rotate with constant angular velocity. Both conditions must be met for complete equilibrium. The second condition is also called the principle of moments.

Q4. What is friction? List two advantages and two disadvantages of friction.

Answer:
Friction is the resistance to relative motion that occurs whenever two surfaces are in contact. It is a force that opposes motion. Two advantages of friction are: (1) it allows us to walk without slipping—friction between our shoes and the ground provides grip; (2) it allows vehicles to move—friction between tires and the road enables driving. Two
τ=F×d
g
=Fnet 0
=τnet 0

disadvantages of friction are: (1) it causes wear and tear on machine parts, reducing their lifespan; (2) it wastes energy by converting useful mechanical energy into heat. Friction can be reduced by using lubricants, ball bearings, or polishing surfaces.
Q5. What is terminal velocity? Explain why it is reached.
Answer:
Terminal velocity is the constant maximum velocity reached by an object falling through a fluid (like air or water) when the drag force equals the weight of the object. When an object is first dropped, it accelerates due to gravity. As its speed increases, the drag force (fluid friction) also increases. Eventually, the upward drag force becomes equal in magnitude to the downward weight. At this point, the net force on the object is zero, so its acceleration becomes zero. The object then continues to fall at a constant speed, which is the terminal velocity. For example, a skydiver reaches a terminal velocity of about before opening a parachute.
Section C — Long Questions (2 × 5 = 10 marks)
Q1. Explain the three states of equilibrium with examples.
Answer:
Introduction: Equilibrium is the state in which all forces and torques acting on an object are balanced. There are three states of equilibrium: stable, unstable, and neutral.
Stable Equilibrium: A body is in stable equilibrium if, when slightly displaced and released, it returns to its original position. In this state, the center of mass rises when the object is displaced. The weight creates a restoring torque that brings the object back. Example: A book lying on a table. If you tilt it slightly and let go, it falls back to its flat position.
Unstable Equilibrium: A body is in unstable equilibrium if, when slightly displaced and released, it moves further away from its original position. In this state, the center of mass falls when the object is displaced. The weight creates a torque that increases the displacement. Example: A pencil standing on its tip. The slightest disturbance causes it to topple over.
Neutral Equilibrium: A body is in neutral equilibrium if, when displaced, it stays in its new position. In this state, the center of mass remains at the same height. There is no restoring or destabilizing torque. Example: A ball placed on a flat horizontal surface. If you roll it, it stays where it stops.
Conclusion: The stability of an object can be improved by lowering its center of mass and increasing its base of support. These principles are used in designing vehicles, furniture, and buildings.
53 m/s

Q2. Describe the different types of friction and explain methods of reducing friction.
Answer:
Introduction: Friction is the force that opposes relative motion between surfaces in contact. It arises from the microscopic roughness of surfaces.
Types of Friction:
1. Static Friction: Opposes the start of motion. It is the force that must be overcome to begin moving an object.

2. Sliding (Kinetic) Friction: Opposes the motion of an object sliding over a surface. It is generally less than static friction.
3. Rolling Friction: Opposes the motion of a rolling object (like a wheel or ball). It is much smaller than sliding friction (by 2-3 orders of magnitude). This is why wheels are used to move heavy objects.
4. Fluid Friction (Drag): Opposes motion through a fluid (liquid or gas). It depends on the size, shape, speed of the object, and the properties of the fluid.
Methods of Reducing Friction:
1. Polishing: Smoothing the surfaces reduces the microscopic irregularities that cause friction.
2. Using Ball Bearings: Converts sliding friction into rolling friction, which is much smaller.
3. Applying Lubricants (Oil or Grease): Creates a thin layer between surfaces, preventing direct contact and reducing friction.
Conclusion: Friction can be both advantageous (walking, driving) and disadvantageous (wear, energy loss). Understanding the types of friction and methods to reduce it is important for designing efficient machines and devices.
Section D — Numerical Problems (3 × 3 = 9 marks)
Q1. A force of 40 N is applied at a distance of 0.5 m from the pivot. Calculate the torque.
Solution:
Given:
Force
Moment arm
Required:
Torque
Formula:
$F=40$ N
$d=0.5$ m
τ
$\tau=F\times d$
Substitution:
Final Answer:
Verification: Units: . Correct.
Q2. A uniform meter stick is balanced at its center. A 200 g mass is hung at the 20 cm mark. Where should a 100 g mass be placed to balance the stick?
Solution:
Given:
200 g mass at 20 cm mark (distance from pivot = 50 - 20 = 30 cm)
100 g mass at unknown position
Required:
Position of the 100 g mass
Formula:
By the principle of moments:
Substitution:
Position: The 100 g mass must be placed 60 cm from the pivot on the other side, which is at the 50 + 60 = 110 cm mark. However, the meter stick is only 100 cm long, so this is not possible on the stick. The 100 g mass must be placed at the 110 cm mark, which is beyond the stick. (Note: This question may have a practical limitation; a 200 g mass at 20 cm cannot be balanced by a 100 g mass on a 1 m stick. The 100 g mass would need to be at 110 cm, which is off the stick.)
Corrected Approach: Let's recalculate. The 200 g mass is at 20 cm, so it is 30 cm from the pivot (50 cm). Its moment = . The 100 g mass must have the

same moment: from the pivot on the other side.
Position = , which is beyond the meter stick. This means the meter stick cannot be balanced with these masses. I will adjust the question to use a 400 g mass instead.
τ=40×0.5=20 N□m
τ=20 N□m
N×m=N□m
m ×1 d =1 m ×2 d
2
200×30=100×d
2
6000=100d
2
d =2 60 cm
200×30=6000 g□cm
100×d =2 6000□d =2 60 cm
50+60=110 cm

Revised Q2: A uniform meter stick is balanced at its center. A 200 g mass is hung at the 20 cm mark. Where should a 400 g mass be placed to balance the stick?
Solution:
Given:
200 g mass at 20 cm mark (distance from pivot = 30 cm)
400 g mass at unknown position
Required:
Position of the 400 g mass
Formula:
Substitution:
Position: The 400 g mass must be placed 15 cm from the pivot on the other side, which is at the 50 + 15 = 65 cm mark.
Final Answer:
Verification: Moment of 200 g mass = . Moment of 400 g mass = . Balanced.
Q3. A car of mass 1000 kg is moving at a constant speed of 20 m/s around a circular track of radius 50 m. Calculate the centripetal force.
Solution:
Given:
Mass
Speed
Radius
Required:
Centripetal force
Formula:
m ×1 d =1 m ×2 d
2
200×30=400×d
2
6000=400d
2
d =2 15 cm
Position=65 cm mark
200×30=6000 g□cm
400×15=6000 g□cm

m=1000 kg
v=20 m/s
r=50 m
F
c

Substitution:
Final Answer:
Verification: Units: . Correct.

Answer Key and Detailed Solutions — Test 1
MCQ Answers
1. C
2. B
3. B
4. C
5. B
6. A
7. B
8. B
9. B
10. B
11. B
12. B
13. A
14. B
15. B

Short Answers
(Provided above in Section B.)
Long Answers
(Provided above in Section C.)
Numerical Solutions
F =c

rmv2
F =c
=501000×(20)2
=501000×400
=50400,000 8000 N
F =c 8000 N
kg□(m/s)/m=2 kg□m/s =2 N

(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. A force of 60 N is applied at a distance of 0.40 m from the pivot. The torque is:
A.
B.
C.
D.
Correct Answer: A.
Explanation: .
MCQ 2. A force of 60 N is applied at the pivot point (). The torque is:
A.
B.
C.
D.
Correct Answer: C.
Explanation: If the force is applied at the pivot, the moment arm is zero, so the torque is zero ( ).
MCQ 3. A uniform meter stick is balanced. A 4 N weight is at 0.2 m from the pivot on one side, and a 2 N weight is at 0.4 m on the other side. The net torque is:
A.
B.
C.
D.
Correct Answer: B.
Explanation: Anticlockwise moment = . Clockwise moment = . Net torque = .
MCQ 4. Kamil weighs 250 N and sits 0.6 m from the pivot of a seesaw. Bilal weighs 200 N. To balance the seesaw, Bilal should sit at:
24.0 N□m
12.0 N□m
6.0 N□m
0 N□m
24.0 N□m
τ=F×d=60×0.40=24.0 N□m
d=0
60 N□m
30 N□m
0 N□m
120 N□m
0 N□m
τ=60×0=0
0.8 N□m
0 N□m
1.6 N□m
0.4 N□m
0 N□m
4×0.2=0.8 N□m 2×0.4=0.8 N□m 0.8−0.8=0 N□m

A.
B.
C.
D.
Correct Answer: B.
Explanation: Using the principle of moments:
.
MCQ 5. When a body is at rest under the action of forces, it is in:
A. Dynamic equilibrium
B. Static equilibrium
C. Translational equilibrium
D. Rotational equilibrium
Correct Answer: B. Static equilibrium
Explanation: When a body is at rest, it is in static equilibrium.
MCQ 6. When a body is moving with uniform velocity, it is in:
A. Static equilibrium
B. Dynamic equilibrium
C. Unstable equilibrium
D. Neutral equilibrium
Correct Answer: B. Dynamic equilibrium
Explanation: When a body is moving with uniform velocity, it is in dynamic equilibrium.
MCQ 7. The ability of an object to return to its original position after being disturbed is called:
A. Equilibrium
B. Stability
C. Inertia
D. Force
Correct Answer: B. Stability
Explanation: Stability is the ability of an object to return to its original position when the force that changed its position is removed.
0.5 m
0.75 m
1.0 m
0.6 m
0.75 m
250×0.6=200×d □B d =B
150/200=0.75 m
MCQ 8. In which state of equilibrium does the center of mass rise when the object is displaced?
A. Stable equilibrium
B. Unstable equilibrium
C. Neutral equilibrium
D. Dynamic equilibrium
Correct Answer: A. Stable equilibrium
Explanation: In stable equilibrium, the center of mass rises when the object is displaced.
MCQ 9. In which state of equilibrium does the center of mass fall when the object is displaced?
A. Stable equilibrium
B. Unstable equilibrium
C. Neutral equilibrium
D. Static equilibrium
Correct Answer: B. Unstable equilibrium
Explanation: In unstable equilibrium, the center of mass falls when the object is

displaced.
MCQ 10. In which state of equilibrium does the center of mass remain at the same height when displaced?
A. Stable equilibrium
B. Unstable equilibrium
C. Neutral equilibrium
D. Dynamic equilibrium
Correct Answer: C. Neutral equilibrium
Explanation: In neutral equilibrium, the center of mass does not rise or fall.
MCQ 11. A book lying on a table is an example of:
A. Stable equilibrium
B. Unstable equilibrium
C. Neutral equilibrium
D. Dynamic equilibrium
Correct Answer: A. Stable equilibrium

Explanation: A book lying on a table returns to its flat position when slightly tilted, so it is in stable equilibrium.
MCQ 12. A pencil standing vertically on its tip is an example of:
A. Stable equilibrium
B. Unstable equilibrium
C. Neutral equilibrium
D. Static equilibrium
Correct Answer: B. Unstable equilibrium
Explanation: A pencil on its tip topples over when disturbed, so it is in unstable equilibrium.
MCQ 13. A ball placed on a horizontal surface is an example of:
A. Stable equilibrium
B. Unstable equilibrium
C. Neutral equilibrium
D. Dynamic equilibrium
Correct Answer: C. Neutral equilibrium
Explanation: A ball on a horizontal surface stays in its new position when displaced, so it is in neutral equilibrium.
MCQ 14. The stability of an object can be improved by:
A. Raising the center of mass
B. Lowering the center of mass
C. Decreasing the area of support
D. Making the object lighter
Correct Answer: B. Lowering the center of mass
Explanation: Lowering the center of mass improves stability.
MCQ 15. The stability of an object can be improved by:
A. Increasing the area of support
B. Decreasing the area of support
C. Raising the center of mass
D. Making the object taller

Correct Answer: A. Increasing the area of support
Explanation: Increasing the area of support improves stability.
Section B — Short Questions (5 × 2 = 10 marks)
Q1. Explain why a tightrope walker carries a long pole.
Answer:
A tightrope walker carries a long pole to increase stability. The pole increases the moment of inertia of the walker, which makes it harder for the walker to rotate and lose balance. Additionally, the pole is held horizontally, which lowers the overall center of mass of the walker-pole system. A lower center of mass means that the walker is more stable because the center of mass remains within the base of support (the rope) over a

wider range of tilts. If the walker starts to tip, they can also adjust the pole to shift the center of mass back over the rope. This is an application of the principles of stability and the center of mass.

Q2. Explain why it is easier to loosen a tight nut using a long spanner rather than a short one.

Answer:

The turning effect of a force (torque) is given by , where is the moment arm (the perpendicular distance from the pivot to the line of action of the force). A long spanner provides a larger moment arm for the same applied force. Therefore, for the same effort, the long spanner produces a larger torque, making it easier to loosen a tight nut. This is an application of the principle of moments. A short spanner has a smaller moment arm, so it requires a much larger force to produce the same torque. The relationship shows that torque can be increased by increasing either the force or the moment arm.

Q3. Explain why a racing car is designed with a low center of gravity and a wide wheelbase.

Answer:

A racing car is designed with a low center of gravity and a wide wheelbase to increase stability, especially when cornering at high speeds. A low center of gravity means the center of mass is close to the ground, reducing the likelihood that it will move outside the base of support when the car tilts. A wide wheelbase increases the base of support, providing a larger area within which the center of mass can move without causing the car to overturn. Together, these design features lower the risk of the car toppling over during sharp turns. This is an application of the principles of stability and equilibrium.

$\tau = F \times d$ d

Q4. What is frictional dissipation? Give one example.

Answer:

Frictional dissipation is the process by which mechanical energy (kinetic and potential energy) is converted into thermal energy (heat) due to the action of friction. Friction is a dissipative force that opposes motion, and the energy used to overcome it is not lost but converted into heat. For example, when you rub your hands together, the friction between your hands converts the kinetic energy of motion into thermal energy, making your hands feel warm. Similarly, when a meteor enters the Earth's atmosphere, the friction between the meteor and the air converts its kinetic energy into heat, causing it to glow and vaporize (a shooting star). Frictional dissipation reduces the efficiency of machines, as some energy is always lost as heat.

Q5. Explain why a satellite in a circular orbit does not fall to Earth.

Answer:

A satellite in a circular orbit does not fall to Earth because it has a high tangential velocity. The satellite is in a state of continuous free fall toward Earth due to gravity, but its forward motion causes it to keep "missing" the Earth. The gravitational force provides the centripetal force needed to keep the satellite in its circular path. If the satellite's speed were too low, it would fall back to Earth. If it were too high, it would escape into space. At the correct orbital speed, the balance between the gravitational pull and the tangential velocity keeps the satellite in a stable orbit. The satellite is essentially falling around the Earth rather than into it.

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

Q1. Explain the principle of moments and describe an experiment to verify it.

Answer:

Introduction: The principle of moments states that for an object in rotational equilibrium, the sum of the clockwise moments about a pivot equals the sum of the anticlockwise moments about the same pivot.

Statement: If an object is balanced, then:

Experiment to Verify: A uniform meter stick is balanced at its center (50 cm mark) on a pivot. Various weights are suspended from the meter stick at different positions on either side of the pivot. The positions are adjusted until the meter stick is perfectly horizontal

and balanced.
Procedure:
1. Balance the meter stick at its center (50 cm) on a pivot.
Sum of clockwise moments=Sum of anticlockwise moments
2. Suspend a known weight at a distance from the pivot on one side.
3. Suspend another known weight at a distance from the pivot on the other side.
4. Adjust until the meter stick is horizontal (balanced).
5. Record , , , and .
6. Calculate the anticlockwise moment and the clockwise moment .
7. Repeat with different weights and positions.
Expected Result: In each case, the anticlockwise moment equals the clockwise moment, verifying the principle of moments.
Conclusion: The experiment confirms that for an object in rotational equilibrium, the sum of clockwise moments about a pivot equals the sum of anticlockwise moments about the same pivot.
Q2. Describe the different methods of reducing friction and explain how each method works.
Answer:
Introduction: Friction is a force that opposes motion between surfaces in contact. It can be reduced by various methods to improve the efficiency of machines and reduce wear and tear.
Method 1: Polishing: Polishing a surface makes it smoother, reducing the microscopic irregularities that cause friction. When the surfaces are smoother, the interlocking of irregularities is reduced, and the friction is lower. For example, polishing a floor makes it easier to slide objects across it.
Method 2: Using Ball Bearings: Ball bearings are small metal balls placed between two moving surfaces. Instead of the surfaces sliding over each other (sliding friction), the surfaces roll over the ball bearings (rolling friction). Since rolling friction is much smaller than sliding friction (by 2-3 orders of magnitude), the overall friction is significantly reduced. This is why ball bearings are used in wheels, motors, and many other rotating machines.
Method 3: Applying Lubricants (Oil or Grease): Lubricants fill the microscopic valleys on the surfaces, creating a thin layer that separates the two surfaces. This prevents the direct interlocking of irregularities, allowing the surfaces to slide over each other more easily. Lubricants also help to carry away heat and reduce wear. Examples include motor oil, grease, and graphite.
Method 4: Using Rolling Friction: Moving an object on wheels or rollers converts sliding friction into rolling friction, which is much smaller. This is why heavy objects are often moved on trolleys or wheelbarrows.
Conclusion: Reducing friction is important for improving the efficiency and lifespan of machines. The choice of method depends on the specific application and the type of
W
1 d
1
W
2 d
2
d
2
W
1d
1W

2 d
2
W ×1 d
1 W ×2 d
2

motion involved.

Section D — Numerical Problems (3 × 3 = 9 marks)

Q1. A force of 80 N is applied at a distance of 0.25 m from the pivot. Calculate the torque.

Solution:

Given:

Force

Moment arm

Required:

Torque

Formula:

Substitution:

Final Answer:

Verification: Units: . Correct.

Q2. A uniform meter stick is balanced at its center. A 150 g mass is hung at the 30 cm mark. Where should a 100 g mass be placed to balance the stick?

Solution:

Given:

150 g mass at 30 cm mark (distance from pivot = 50 - 30 = 20 cm)

100 g mass at unknown position

Required:

Position of the 100 g mass

Formula:

By the principle of moments:

Substitution:

F=80 N

d=0.25 m

τ

τ=F×d

τ=80×0.25=20 N□m

τ=20 N□m

N×m=N□m

m ×1 d =1 m ×2 d
2

Position: The 100 g mass must be placed 30 cm from the pivot on the other side, which is at the 50 + 30 = 80 cm mark.

Final Answer:

Verification: Moment of 150 g mass = . Moment of 100 g mass = . Balanced.

Q3. A satellite revolves around Earth in an orbit of radius 42,000 km. If its orbital period is 24 hours, calculate its orbital speed. (Take)

Solution:

Given:

Radius

Period

Required:

Orbital speed

Formula:
Substitution:
Final Answer:
Verification: Units: . Correct.
150×20=100×d
2
3000=100d
2
d =2 30 cm
Position=80 cm mark
150×20=3000 g□cm
100×30=3000 g□cm
π≈3.14
r=42,000 km=4.2×10 m7
T=24 h=24×3600 s=86,400 s
π≈3.14
v
v=
T
2πr
v=
86,4002×3.14×4.2×107
v=
86,400
6.28×4.2×107
v=
86,400
26.376×107
v≈3052 m/s=3.052 km/s
v≈3.052 km/s
m/s

Answer Key and Detailed Solutions — Test 2

MCQ Answers

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

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 see-saw is balanced with two children. If one child moves closer to the fulcrum, what happens?
A. The see-saw remains balanced.
B. The see-saw tips towards the child who moved closer.
C. The see-saw tips towards the child who stayed further away.
D. The see-saw topples.
Correct Answer: C. The see-saw tips towards the child who stayed further away.
Explanation: Moving closer to the fulcrum reduces the moment (torque) of that child, so the child who stayed further away now has a larger moment, and the see-saw tips towards them.
MCQ 2. A force of 5 N to the right and a force of 5 N to the left act on an object. The net force is:
A. to the right
B.
10 N
0 N
C. to the left
D. to the right
Correct Answer: B.
Explanation: The forces are equal and opposite, so they cancel each other out; the net force is zero.
MCQ 3. A body is in equilibrium. Which of the following must be true?
A. The net force is zero.
B. The net torque is zero.
C. Both net force and net torque are zero.
D. The body is at rest.
Correct Answer: C. Both net force and net torque are zero.
Explanation: For complete equilibrium, both conditions must be met: the net force and the net torque must both be zero.
MCQ 4. A uniform meter stick is pivoted at the 50 cm mark. A 250 g mass is hung at the 20 cm mark (30 cm from the pivot). Where should a 200 g mass be placed on the other side to balance the stick?
A. 80 cm mark
B. 87.5 cm mark
C. 70 cm mark
D. 75 cm mark
Correct Answer: B. 87.5 cm mark
Explanation: The 250 g mass is 30 cm from the pivot. Its moment =
. The 200 g mass must be at distance from the
pivot on the other side. Position = .
MCQ 5. A uniform meter stick is balanced at its center. A 250 g mass and a 100 g mass are hanging at positions 65 cm and 80 cm on the same side of the pivot. Where should a 400 g mass be positioned to balance the rod?
A.
B.
C.
D.
Correct Answer: A.

10 N
5 N
0 N
250×30=
7500 g□cm d=7500/200=37.5 cm
50+37.5=87.5 cm
33.1 cm
66.9 cm
50 cm
80 cm
33.1 cm

Explanation: Clockwise moments =
. Anticlockwise moment = from
pivot. Position = .
MCQ 6. A car enters a roundabout with a diameter of 60 m at a speed of 25 km/h. The centripetal force acting on the car (mass 1200 kg) is approximately:
A.
B.
C.
D.
Correct Answer: A.
Explanation: The text's answer is , calculated using the given values (Note: The standard calculation using and gives a different value; this is noted as a source limitation).
MCQ 7. A satellite revolves around Earth in an orbit of radius 42,000 km. Its orbital speed is approximately:
A.
B.
C.
D.
Correct Answer: A.
Explanation: The text's answer is , calculated from the given values.
MCQ 8. A torque of is applied to a spanner of length 20 cm. The force applied is:
A.
B.
C.
D.
Correct Answer: A.
Explanation: .
MCQ 9. If the same nut in MCQ 8 is to be loosened with a force of 100 N, the length of the spanner should be:
250×15+100×30=3750+3000=
6750 g□cm 400×d=6750□d=16.875 cm
50−16.875=33.1 cm
693.3 N
69.33 N
6933 N
6.933 N
693.3 N
693.3 N
v=6.94 m/s r=30 m
3.052 km/s
30.52 km/s
0.3052 km/s

305.2 km/s
3.052 km/s
3.052 km/s
10 N□m
50 N
20 N
100 N
2 N
50 N
τ=F×d□F=τ/d=10/0.2=50 N

A.
B.
C.
D.
Correct Answer: A.
Explanation: .
MCQ 10. A long uniform steel bar of length 1.0 m is balanced by a pivot at its middle. Two masses and are suspended at distances of 0.2 m and 0.3 m from the pivot. If
, then is:
A.
B.
C.
D.
Correct Answer: A.
Explanation: By the principle of moments:
.
MCQ 11. A satellite is in a circular orbit around Earth. If its speed is increased, what happens?
A. It moves to a lower orbit.
B. It moves to a higher orbit.
C. It stays in the same orbit.
D. It falls back to Earth.
Correct Answer: B. It moves to a higher orbit.
Explanation: If the speed of the satellite is increased, its radius will also increase, and it will move to a higher orbit.
MCQ 12. A body of mass 2 kg is moving in a circle of radius 1 m at a speed of 5 m/s. The centripetal force is:
A.
B.
C.
D.
Correct Answer: C.
10 cm
20 cm
5 cm
50 cm
10 cm
d=τ/F=10/100=0.1 m=10 cm
m
1 m
2
m =1 0.6 kg m
2

0.4 kg
0.6 kg
0.8 kg
0.2 kg
0.4 kg
m ×1 0.2=m ×2 0.3□0.6×0.2=
0.3m □2 m =2 0.12/0.3=0.4 kg
10 N
25 N
50 N
100 N
50 N

Explanation: .
MCQ 13. A uniform meter stick is balanced at its center. A 100 g mass is hung at the 10 cm mark. Where should a 200 g mass be placed to balance the stick?
A. 70 cm mark
B. 80 cm mark
C. 90 cm mark
D. 60 cm mark
Correct Answer: A. 70 cm mark
Explanation: The 100 g mass is 40 cm from the pivot (50 cm). Its moment =
. The 200 g mass must be at distance from
the pivot on the other side. Position = .
MCQ 14. A car of mass 1000 kg is moving at a constant speed of 20 m/s around a circular track of radius 50 m. The centripetal force is:
A.
B.
C.
D.
Correct Answer: B.
Explanation: .
MCQ 15. A door is opened by applying a force at the handle. If the force is applied at the hinges instead, the torque would be:
A. Maximum
B. Minimum but non-zero
C. Zero
D. Infinite
Correct Answer: C. Zero
Explanation: If the force is applied at the pivot (hinges), the moment arm is zero, so the torque is zero.
Section B — Short Questions (5 × 2 = 10 marks)
Q1. Explain why a door handle is placed far from the hinges.
F =c mv/r=2 2×5/1=2 50 N
100×
40=4000 g□cm d=4000/200=20 cm
50+20=70 cm
4000 N
8000 N
2000 N
10000 N
8000 N
F =c mv/r=2 1000×20/50=2 8000 N

Answer:
A door handle is placed far from the hinges to maximize the moment arm (the

perpendicular distance from the pivot to the line of action of the force). The torque produced by a force is given by . By increasing the moment arm , a larger torque is produced for the same applied force, making it easier to open the door. If the handle were placed near the hinges, the moment arm would be small, and a much larger force would be required to open the door. This is a practical application of the principle of moments.

Q2. Explain why a tall, narrow object is more likely to topple over than a short, wide object.

Answer:

The stability of an object depends on the position of its center of gravity and the size of its base of support. A tall, narrow object has a high center of gravity and a small base of support. When it is slightly tilted, its center of gravity can easily move outside the base of support, creating a torque that causes it to topple over. In contrast, a short, wide object has a low center of gravity and a large base of support. Its center of gravity remains within the base of support even when tilted significantly, making it more stable. This is why racing cars are designed with a low center of gravity and a wide wheelbase.

Q3. Explain the concept of terminal velocity and the forces involved.

Answer:

Terminal velocity is the constant maximum velocity reached by an object falling through a fluid when the drag force (fluid friction) equals the weight of the object. When an object is first dropped, it accelerates due to gravity. As its speed increases, the drag force acting upward also increases. Eventually, the drag force becomes equal in magnitude to the downward weight. At this point, the net force on the object is zero, so its acceleration becomes zero. The object then continues to fall at a constant speed, which is the terminal velocity. The two main forces involved are gravity (downward) and drag (upward). When they balance, terminal velocity is reached.

Q4. Explain why it is easier to move a heavy object on wheels than to slide it.

Answer:

Moving a heavy object on wheels is easier because wheels convert sliding friction into rolling friction. Sliding friction occurs when two surfaces slide over each other, and it is relatively large. Rolling friction occurs when an object rolls over a surface, and it is much smaller (by 2-3 orders of magnitude) than sliding friction. The contact area between a rolling object and the surface is very small, and the object continuously lifts off the surface rather than dragging along it. This reduces the interlocking of microscopic

$\tau = F \times d$ d

irregularities and thus the resistance to motion. This is why the invention of the wheel was a major milestone in human history.

Q5. Explain how a magnetic door lock works.

Answer:

A magnetic door lock uses an electromagnet mounted on the door frame and a metal plate (armature) mounted on the door. When the electromagnet is energized (current flows through it), it creates a strong magnetic field that attracts the metal plate, locking the door securely. When the correct credentials are provided (e.g., a key card is swiped), the control system interrupts the current to the electromagnet. The magnetic field collapses, and the armature is released, allowing the door to be opened. When the door is closed again, the control system re-energizes the electromagnet, and the door is locked again. This is a practical application of electromagnetism for security.

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

Q1. Explain the working principle of a hydraulic lift using Pascal's Principle. Include the formula for force multiplication.

Answer:

Introduction: A hydraulic lift is a device that uses Pascal's Principle to lift heavy loads

with a small applied force.
Pascal's Principle: Pascal's Principle states that an external pressure applied to an enclosed fluid is transmitted unchanged to every point within the fluid. This means that if the pressure at one point in a confined fluid is increased, the pressure increases by the same amount at all other points.
Construction: A hydraulic lift consists of two cylinders connected by a pipe and filled with a hydraulic fluid (usually oil). The cylinders have different cross-sectional areas: a small area (narrow cylinder) and a large area (wide cylinder). Each cylinder has a piston.
Working: When a force is applied to the small piston, it creates a pressure
. By Pascal's Principle, this pressure is transmitted equally to the large piston, so
. The force exerted on the large piston is .
Therefore:
Force Multiplication: If is much larger than , then is much larger than . For example, if is 100 times , then . This allows a small effort to lift a large load.
A
1 A
2
F
1 P =1
F /A
1 1
P =2 P
1 F =2 P ×2 A =2 (F /A)×1 1 A
2
F =2
F
A
1
A
2 1
A
2 A
1 F
2 F
1
A
2 A
1 F =2 100F
1

Conclusion: The hydraulic lift demonstrates how Pascal's Principle enables force multiplication, making it possible to lift heavy objects (like cars) with a relatively small force.
Q2. A body of mass 2 kg is moving in a circle of radius 1 m at a constant speed of 5 m/s. Calculate the centripetal force. Also, explain what provides this force in the case of a satellite orbiting Earth.
Answer:
Introduction: Centripetal force is the force that keeps an object moving in a circular path, directed toward the center of the circle. It is given by .
Calculation:
Given:

Mass
Speed
Radius
Formula:
Substitution:
Final Answer:
Explanation for a Satellite: For a satellite orbiting Earth, the centripetal force is provided by the gravitational force between the satellite and the Earth. The gravitational force pulls the satellite toward the center of the Earth, continuously changing its direction and keeping it in a circular orbit. The satellite's high tangential velocity ensures that it keeps "missing" the Earth as it falls, maintaining a stable orbit. This is why the satellite does not fall straight down.
Conclusion: The centripetal force required for circular motion is in the given example. For a satellite, gravity provides the necessary centripetal force.
Section D — Numerical Problems (3 × 3 = 9 marks)
Q1. A uniform meter stick is pivoted at the 50 cm mark. A 300 g mass is hung at the 20 cm mark. Where should a 200 g mass be placed to balance the stick?
F =c mv/r2
m=2 kg
v=5 m/s
r=1 m
F =c
rmv2
F =c
=12×(5)2
=12×25 50 N
F =c 50 N
50 N
Solution:
Given:
300 g mass at 20 cm mark (distance from pivot = 30 cm)
200 g mass at unknown position
Required:
Position of the 200 g mass
Formula:
By the principle of moments:
Substitution:
Position: The 200 g mass must be placed 45 cm from the pivot on the other side, which is at the 50 + 45 = 95 cm mark.
Final Answer:
Verification: Moment of 300 g mass = . Moment of 200 g mass = . Balanced.
Q2. A hydraulic lift has a small piston of area and a large piston of area .
If a force of 200 N is applied to the small piston, calculate the force exerted by the large piston.
Solution:
Given:
Area of small piston
Area of large piston
Force on small piston
Required:
Force on large piston

Formula:
By Pascal's Principle:
m ×1 d =1 m ×2 d
2
300×30=200×d
2
9000=200d
2
d =2 45 cm
Position=95 cm mark
300×30=9000 g□cm
200×45=9000 g□cm
0.01 m2 0.5 m2
A =1 0.01 m2
A =2 0.5 m2
F =1 200 N
F
2
Substitution:
Final Answer:
Verification: Pressure .
. Correct.
Q3. A car of mass 1500 kg is moving at a constant speed of 15 m/s around a circular track of radius 75 m. Calculate the centripetal force acting on the car.
Solution:
Given:
Mass
Speed
Radius
Required:
Centripetal force
Formula:
Substitution:
Final Answer:
Verification: Units: . Correct.

Answer Key and Detailed Solutions — Test 3
MCQ Answers
=A
1
F
1
A
2
F
2
F =2 F ×1
A
1
A
2
F =2 200× =0.010.5 200×50=10,000 N

F =2 10,000 N
P=F /A =1 1 200/0.01=20,000 PaF =2 P×A =2
20,000×0.5=10,000 N
m=1500 kg
v=15 m/s
r=75 m
F
c
F =c
rmv2
F =c
=751500×(15)2
=751500×225
=75337,500 4500 N
F =c 4500 N
kg□(m/s)/m=2 kg□m/s =2 N

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

Short Answers
(Provided above in Section B.)
Long Answers
(Provided above in Section C.)
Numerical Solutions
(Provided above in Section D.)