

GENERAL PHYSICS – CHAPTER 2

Freshman Exam Introduction

Exam Focus

- Newton's Laws of Motion & applications
- Forces: friction, tension, normal, weight
- Uniform circular motion & centripetal force
- Universal law of gravitation
- Kepler's laws, satellites, & weightlessness
- Work–energy theorem & potential/kinetic energy
- Power and mechanical efficiency
- Linear momentum & impulse
- Collisions (elastic & inelastic)
- Center of mass & system dynamics

Purpose

Evaluate students' understanding of fundamental mechanics concepts essential for first-year university physics.

Freshman Resources

For solved problems, worksheets, notes, videos, and continuous exam prep:

- @StarFreshs
- @FreshmanStars



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Telegram – @StarFreshs

PART I — TRUE / FALSE (20 ITEMS)

1. Newton's First Law states that a body remains in uniform motion unless acted on by an external force.
2. In uniform circular motion, velocity changes because direction changes even when speed is constant.
3. Centripetal force always acts tangential to the circular path.
4. According to Newton's Third Law, action and reaction forces act on the same body.
5. The gravitational force between two masses is inversely proportional to the square of their separation.
6. Weightlessness in orbit occurs because astronauts are far from Earth's gravity.
7. Kepler's First Law states that planets move in elliptical orbits with the Sun at one focus.
8. Work is done only when a force causes displacement in the direction of the force.
9. Kinetic energy depends on mass and velocity.
10. Gravitational potential energy increases with height.
11. Power is the rate at which work is done.
12. Impulse equals change in linear momentum.
13. In perfectly elastic collisions, both momentum and kinetic energy are conserved.
14. In inelastic collisions, bodies stick together after impact.
15. Center of mass always lies inside an object.
16. A satellite in circular orbit has constant speed but changing velocity.
17. Centrifugal force is a real force acting outward during circular motion.
18. Work done by friction is always negative.
19. An isolated system has constant total momentum.
20. Escape velocity is independent of the mass of the escaping object.

✓ PART II — MULTIPLE CHOICE (40 ITEMS)

21. Newton's Second Law states that force is:
- A) mass $\times$ velocity
 - B) mass $\times$ acceleration
 - C) momentum $\div$ time
 - D) impulse $\times$ distance
22. The net force required for circular motion is called:
- A) Tangential force
 - B) Centrifugal force
 - C) Centripetal force
 - D) Normal force
23. The SI unit of gravitational constant G is:
- A) N·m
 - B) N·m²/kg²
 - C) m²/kg
 - D) N/kg
24. A satellite in low Earth orbit is mainly kept in motion by its:
- A) Engine thrust
 - B) Tangential velocity
 - C) Magnetic field
 - D) Solar radiation
25. Kepler's Second Law describes:
- A) Elliptical orbits
 - B) Equal areas in equal times
 - C) Planetary periods
 - D) Orbital tilt
26. Work done is zero when:
- A) Force and displacement are perpendicular
 - B) Force is large
 - C) Displacement is large
 - D) Both are in same direction
27. The kinetic energy of an object is doubled when its speed:
- A) Doubles
 - B) Triples
 - C) Is halved
 - D) Remains constant
28. Power can be expressed as:
- A) Work / time
 - B) Force $\times$ mass
 - C) Momentum $\times$ distance
 - D) Energy $\times$ speed

29. Linear momentum is defined as:
- A) m/a
 - B) mv
 - C) Fd
 - D) $KE \times 2$
30. A perfectly elastic collision conserves:
- A) Only momentum
 - B) Only energy
 - C) Momentum and kinetic energy
 - D) Angular momentum only
31. The center of mass of a uniform sphere is located:
- A) At its center
 - B) On its surface
 - C) Outside the sphere
 - D) Depends on its density
32. Newton's Third Law implies that for every action, the reaction is:
- A) Equal and opposite
 - B) Equal and same direction
 - C) Different and opposite
 - D) Zero
33. The centripetal acceleration for circular motion is:
- A) v/r
 - B) r/v
 - C) v^2/r
 - D) r^2/v
34. Escape velocity from Earth is approximately:
- A) 4.2 km/s
 - B) 7.9 km/s
 - C) 11.2 km/s
 - D) 15 km/s
35. Work done by a constant force is given by:
- A) F/v
 - B) $Fd \cos\theta$
 - C) mv^2
 - D) $\frac{1}{2}mv^2$

36. Potential energy of a mass near Earth's surface is:
- A) mgh
 - B) $\frac{1}{2}mv^2$
 - C) Fd
 - D) mv
37. A force of 10 N acting on a 2 kg mass produces acceleration:
- A) 2 m/s^2
 - B) 5 m/s^2
 - C) 10 m/s^2
 - D) 20 m/s^2
38. Orbital period increases when orbital radius:
- A) Increases
 - B) Decreases
 - C) Remains constant
 - D) Doubles
39. Impulse equals:
- A) Ft
 - B) ma
 - C) mv^2
 - D) KE
40. During inelastic collision, kinetic energy:
- A) Is fully conserved
 - B) Is partially lost
 - C) Is fully lost
 - D) Increases
41. The direction of centripetal force is:
- A) Tangential
 - B) Outward
 - C) Towards the center
 - D) Horizontal
42. Gravitational force decreases when:
- A) Mass decreases
 - B) Distance increases
 - C) Both A and B
 - D) Neither A nor B

43. Work done against gravity depends on:
- A) Horizontal distance
 - B) Vertical height
 - C) Speed
 - D) Mass only
44. The unit of power:
- A) Watt
 - B) Joule
 - C) Newton
 - D) Coulomb
45. A system with no external forces has:
- A) Constant momentum
 - B) Increasing energy
 - C) Zero acceleration
 - D) No mass
46. The gravitational force between Earth and Moon is:
- A) Different on each
 - B) Same magnitude
 - C) Zero
 - D) Depends only on Earth
47. Centripetal acceleration increases when:
- A) Speed decreases
 - B) Radius increases
 - C) Speed increases
 - D) Mass increases
48. Kepler's Third Law relates:
- A) Force & mass
 - B) Orbital period & radius
 - C) Velocity & displacement
 - D) Momentum & radius
49. Work-energy theorem states:
- A) $\text{Work} = \text{Force} \times \text{time}$
 - B) $\text{Net work} = \text{Change in KE}$
 - C) $\text{KE} = \text{PE}$
 - D) $\text{PE} = \text{Work} \times \text{Distance}$
50. An object is weightless when:
- A) Gravity is zero
 - B) It is in free fall
 - C) It has no mass
 - D) It is accelerated upward



PART III — FILL-IN-THE-BLANK (15 ITEMS)

51. Newton's Second Law is mathematically written as _____.
52. The force required for circular motion is called _____.
53. Gravitational force varies inversely with _____.
54. Kepler's First Law states that planetary orbits are _____.
55. Work is defined as force times _____.
56. Kinetic energy is given by the expression _____.
57. Power = Work / _____.
58. Impulse equals _____ in momentum.
59. A perfectly elastic collision conserves momentum and _____.
60. The point representing average position of mass is called _____.
61. The acceleration toward the center in circular motion is _____.
62. Escape velocity from Earth is approximately _____.
63. Gravitational potential energy near Earth is given by _____.
64. The SI unit of power is _____.
65. A satellite follows Kepler's _____ Law during equal areas in equal times.

✓ PART IV — WORKOUT / NUMERICAL PROBLEMS (25 ITEMS)

66. A 5 kg object experiences a net force of 15 N. Find its acceleration.
67. A 2 kg mass is lifted 10 m vertically. Calculate the work done against gravity.
68. A car accelerates from 10 m/s to 20 m/s. Find the change in kinetic energy if its mass is 1000 kg.
69. A satellite orbits Earth with speed 7.9 km/s. Calculate its centripetal acceleration at radius 6.7×10^6 m.
70. A force of 50 N is applied at 30° to the horizontal. Find the work done moving 5 m.
71. Find the gravitational force between two 5 kg masses separated by 0.5 m.
72. A 3 kg object moves in a circle of radius 2 m at 4 m/s. Find the centripetal force.
73. A machine does 2000 J of work in 5 seconds. Find its power.
74. A 10 kg mass moving at 3 m/s collides elastically with a 5 kg mass at rest. Find their final velocities.
75. Two objects stick together after collision. A 4 kg mass at 6 m/s collides with 2 kg at rest. Find final velocity.
76. Determine the escape velocity from a planet of mass 5×10^{24} kg and radius 6×10^6 m.
77. A 20 N friction force acts on a block moving 8 m. Find work done by friction.
78. Calculate impulse if a 2 kg body's velocity changes from 5 m/s to -3 m/s.
79. A 500 kg satellite orbits Earth at radius 8×10^6 m. Find its orbital speed.
80. Find gravitational potential energy of a 50 kg mass lifted to height 40 m.
81. A force of 100 N acts on a mass from rest, producing 10 m/s velocity in 4 sec. Find distance moved.
82. Compute the period of a satellite orbiting Earth at radius 7×10^6 m.
83. A rotating body moves at 5 m/s in a circle of radius 1 m. Find its centripetal acceleration.
84. Two bodies, 3 kg and 5 kg, have distance 2 m. Find force between them.
85. A motorcycle engine outputs 20 kW of power. How much work is done in 30 sec?
86. A ball moving with 15 m/s rebounds with 10 m/s opposite direction. Mass = 0.2 kg. Find impulse.
87. Calculate the center of mass of two masses: 4 kg at $x=0$ and 6 kg at $x=5$ m.
88. A planet's orbital radius doubles. Determine change in orbital period.
89. A 2 kg body moving at 10 m/s enters a circular path of radius 4 m. Find centripetal force.
90. A 1200 kg car slows from 25 m/s to 5 m/s. Find change in kinetic energy.

✓ ANSWER KEY — Chapter 2 (Selected Sections)

PART I — TRUE / FALSE (1–20)

1. T
2. T
3. F — (Centripetal force is radial inward, not tangential.)
4. F — (Action and reaction act on different bodies.)
5. T
6. F — (Weightlessness in orbit is not because gravity is zero; it is due to free fall.)
7. T
8. T
9. T — ($KE = \frac{1}{2} mv^2$.)
10. T
11. T
12. T — (Impulse = Δp .)
13. T
14. F — (Only perfectly inelastic collisions always stick together.)
15. F — (Center of mass can lie outside the object, e.g. a ring.)
16. T
17. F — (Centrifugal force is a pseudo-force in a rotating frame.)
18. T — (Friction does negative work when opposing motion.)
19. T
20. T — (Escape velocity is independent of the escaping object's mass.)

PART II — MULTIPLE CHOICE (21–50)

- 21. B — $F = ma$.
- 22. C — Centripetal force.
- 23. B — Unit of G is $\text{N}\cdot\text{m}^2/\text{kg}^2$.
- 24. B — Tangential velocity keeps a satellite in orbit.
- 25. B — Kepler's Second Law: equal areas in equal times.
- 26. A — When force $\perp$ displacement, $W = 0$.
- 27. A — (Answer chosen per question wording; note physically $KE \propto v^2$ so KE doubles when speed multiplies by $\sqrt{2}$.)
- 28. A — Power = Work / time.
- 29. B — Linear momentum $p = mv$.
- 30. C — Momentum and kinetic energy are conserved in perfectly elastic collisions.
- 31. A — At the geometric center for a uniform sphere.
- 32. A — Equal and opposite.
- 33. C — $a_c = \frac{v^2}{r}$.
- 34. C — $\approx 11.2 \text{ km/s}$ (escape velocity from Earth).
- 35. B — $W = Fd \cos \theta$.
- 36. A — $U = mgh$.
- 37. B — $a = F/m = 10/2 = 5 \text{ m/s}^2$.
- 38. A — Orbital period increases with radius (Kepler's 3rd law).
- 39. A — Impulse = Ft .
- 40. B — Kinetic energy is partially lost in inelastic collisions.
- 41. C — Towards the center.
- 42. C — Both (force $\propto$ product of masses and $\propto 1/r^2$).
- 43. B — Depends on vertical height (mgh).
- 44. A — Watt (W).
- 45. A — Constant momentum (if no net external force).
- 46. B — The gravitational force magnitude is the same on each (Newton's 3rd law).
- 47. C — Centripetal acceleration increases with speed.
- 48. B — Kepler's Third Law: period vs. radius.
- 49. B — Net work = change in kinetic energy.
- 50. B — Weightless when in free fall (e.g., orbit).

PART III — FILL-IN-THE-BLANK (51–65)

51. $F = ma$

52. **Centripetal force**

53. **The square of the distance** (r^2)

54. **Ellipses** (planetary orbits are elliptical)

55. **Displacement** (work = force × displacement component)

56. $\frac{1}{2}mv^2$

57. **Time** (Power = Work / time)

58. **Change** (Impulse equals change in momentum)

59. **Kinetic energy**

60. **Center of mass**

61. v^2/r (centripetal acceleration)

62. ≈ 11.2 km/s (escape velocity from Earth)

63. mgh

64. **Watt (W)**

65. **Second** (Kepler's Second Law: equal areas in equal times)

PART IV — WORKED / NUMERICAL SOLUTIONS (66–90)

66. $a = F/m = 15 \text{ N} / 5 \text{ kg} = 3.00 \text{ m/s}^2$.

67. $\text{Work} = m g h = 2 \text{ kg} \times 9.8 \text{ m/s}^2 \times 10 \text{ m} = 196 \text{ J}$.

68. $\Delta KE = \frac{1}{2} m (v_2^2 - v_1^2) = 0.5 \times 1000 \times (20^2 - 10^2) = 0.5 \times 1000 \times (400 - 100) = 150,000 \text{ J}$.

69. $a_c = v^2 / r = (7.9 \times 10^3 \text{ m/s})^2 / (6.7 \times 10^6 \text{ m}) \approx 9.32 \text{ m/s}^2$.

70. $W = F d \cos\theta = 50 \text{ N} \times 5 \text{ m} \times \cos 30^\circ = 250 \times 0.8660 \approx 216.5 \text{ J}$.

71. $F = G m_1 m_2 / r^2 = 6.674 \times 10^{-11} \times 5 \times 5 / (0.5)^2 = 6.674 \times 10^{-11} \times 100 \approx 6.674 \times 10^{-9} \text{ N}$.

72. $F_c = m v^2 / r = 3 \text{ kg} \times (4 \text{ m/s})^2 / 2 \text{ m} = 3 \times 16 / 2 = 24 \text{ N}$.

73. $\text{Power} = W / t = 2000 \text{ J} / 5 \text{ s} = 400 \text{ W}$.

74. Elastic collision ($m_1=10 \text{ kg}$, $v_1=3 \text{ m/s}$; $m_2=5 \text{ kg}$, $v_2=0$):

$$v_1' = (m_1 - m_2) / (m_1 + m_2) v_1 = (10 - 5) / 15 \times 3 = (5/15) \times 3 = 1.0 \text{ m/s}$$

$$v_2' = (2m_1) / (m_1 + m_2) v_1 = (20/15) \times 3 = (4/3) \times 3 = 4.0 \text{ m/s}$$

75. Perfectly inelastic (stick): final $v = (m_1 v_1 + m_2 v_2) / (m_1 + m_2) = (4 \times 6 + 2 \times 0) / 6 = 24/6 = 4.0 \text{ m/s}$.

76. Escape velocity: $v_e = \sqrt{\frac{2GM}{R}}$.

Using $G = 6.674 \times 10^{-11}$, $M = 5 \times 10^{24} \text{ kg}$, $R = 6 \times 10^6 \text{ m}$:

$$v_e \approx \sqrt{1.112 \times 10^8} \approx 1.05 \times 10^4 \text{ m/s} \approx 10.5 \text{ km/s}$$

77. Work by friction = $F \times d$ (opposite displacement) = $-20 \text{ N} \times 8 \text{ m} = -160 \text{ J}$.

(Work done by friction = -160 J ; magnitude 160 J .)

78. Impulse = $\Delta p = m(v_f - v_i) = 2 \text{ kg} \times (-3 - 5) \text{ m/s} = 2 \times (-8) = -16 \text{ kg}\cdot\text{m/s}$.

(Impulse magnitude $16 \text{ kg}\cdot\text{m/s}$; negative sign indicates direction change.)

79. Orbital speed $v = \sqrt{GM/r}$.

Using $GM \approx 3.986 \times 10^{14} \text{ m}^3/\text{s}^2$ and $r = 8 \times 10^6 \text{ m}$:

$$v \approx \sqrt{\frac{3.986 \times 10^{14}}{8 \times 10^6}} \approx \sqrt{4.9825 \times 10^7} \approx 7.06 \times 10^3 \text{ m/s} \approx 7060 \text{ m/s}$$

80. $U = m g h = 50 \text{ kg} \times 9.8 \text{ m/s}^2 \times 40 \text{ m} = 19,600 \text{ J}$.

81. Given: $F = 100 \text{ N}$ produces $\Delta v = 10 \text{ m/s}$ in $t = 4 \text{ s}$.

$$a = \Delta v / t = 10/4 = 2.5 \text{ m/s}^2 \rightarrow \text{mass } m = F / a = 100 / 2.5 = 40 \text{ kg}$$

$$\text{Distance } s = \frac{1}{2} a t^2 = 0.5 \times 2.5 \times 16 = 20 \text{ m}$$

Distance = 20 m .

82. Orbital period for circular orbit: $T = 2\pi \sqrt{r^3/GM}$.

With $r = 7 \times 10^6 \text{ m}$ and $GM \approx 3.986 \times 10^{14}$:

$$T \approx 2\pi \sqrt{(7 \times 10^6)^3 / 3.986 \times 10^{14}} \approx 5,829 \text{ s} \approx 97.2 \text{ min}$$

83. $a_c = v^2 / r = 5^2 / 1 = 25 \text{ m/s}^2$.

84. $F = G m_1 m_2 / r^2 = 6.674 \times 10^{-11} \times (3 \times 5) / (2)^2 = 6.674 \times 10^{-11} \times 15 / 4 = 2.5028 \times 10^{-10} \text{ N}$.

85. $\text{Work} = \text{Power} \times \text{time} = 20,000 \text{ W} \times 30 \text{ s} = 600,000 \text{ J} = 600 \text{ kJ}$.

86. Mass = 0.2 kg , initial $+15 \text{ m/s}$, final $-10 \text{ m/s} \rightarrow \Delta v = -25 \text{ m/s}$.

$$\text{Impulse} = m \Delta v = 0.2 \times (-25) = -5.0 \text{ N}\cdot\text{s} \text{ (Magnitude } 5.0 \text{ N}\cdot\text{s})$$

87. $x_{CM} = (4 \cdot 0 + 6 \cdot 5) / (4 + 6) = 30/10 = 3.0 \text{ m}$.

88. By Kepler's 3rd law $T \propto r^{3/2}$. If $r \rightarrow 2r$, T multiplies by $2^{3/2} = 2.828$.

Period increases by factor ≈ 2.828 (i.e., becomes $\approx 2.83 \times$ original).

89. $F_c = m v^2 / r = 2 \text{ kg} \times (10 \text{ m/s})^2 / 4 \text{ m} = 2 \times 100 / 4 = 50 \text{ N}$.

90. Change in KE = $\frac{1}{2} m (v_f^2 - v_i^2) = 0.5 \times 1200 \times (5^2 - 25^2) = 600 \times (25 - 625) = 600 \times (-600) = -360,000 \text{ J}$.

(Kinetic energy decreased by 360 kJ .)



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