

AP Physics 1 2024-Style Full Practice Exam

2024-style legacy-format practice exam

Original practice paper. Every question in this PDF was written for Salar Cafe. It does not reproduce official AP exam wording. Models the 2024 legacy paper structure: 45 single-select plus 5 multiple-select MCQs and 5 FRQs.

Section I	50 multiple-choice questions - 90 minutes - 50% (45 single-select + 5 multiple-select)
Section II	5 free-response questions - 90 minutes - 50%
Calculator	Scientific or graphing calculator may be used for this practice paper.
Scoring	MCQ answer key and explanations plus FRQ scoring guidance are included after the exam.
Use	Complete the exam first. Do not consult the answer key until both sections are finished.

Topic emphasis

Energy/circular motion; spring experiment/oscillation; beam torque; pendulum/gravity; elastic collision.

SECTION I - Multiple Choice

50 questions | 90 minutes | Questions 1-45: choose one answer. Questions 46-50: select the TWO correct answers.

1. A 1.5 kg object starts from rest and drops through a vertical height of 0.5 m with negligible friction. What is its speed after the drop?
 - A. 4.9 m/s
 - B. 9.8 m/s
 - C. 3.1 m/s
 - D. 2.2 m/s
2. A 0.20 kg object moves in a horizontal circle of radius 0.8 m at speed 4.0 m/s. What is the required inward net force?
 - A. 1.0 N
 - B. 4.0 N
 - C. 0.01 N
 - D. 0.6 N
3. A 0.40 kg mass oscillates on an ideal spring with $k = 80 \text{ N/m}$. What is the period?
 - A. 0.44 s
 - B. 88.86 s
 - C. 0.07 s
 - D. 0.03 s
4. A force of 20 N is applied at radius 0.25 m from a pivot, making 90 degrees with the radius. What is the torque magnitude about the pivot?
 - A. 80.0 N m
 - B. 5.0 N m
 - C. 0.0 N m
 - D. 6.2 N m
5. A rigid body with rotational inertia 0.20 kg m^2 experiences a net torque of 2.0 N m. What is its angular acceleration?
 - A. 5.0 rad/s^2
 - B. 0.4 rad/s^2
 - C. 10.0 rad/s^2
 - D. 0.10 rad/s^2
6. An ideal small-angle pendulum is moved to a planet where gravitational field strength is 1.44 times Earth's value. Its length is unchanged. What is the new period relative to its Earth period?
 - A. 0.83 times the Earth period
 - B. 1.20 times the Earth period
 - C. 1.44 times the Earth period
 - D. 0.69 times the Earth period

7. A 0.5 kg cart moving at 4.0 m/s collides with and sticks to a stationary 0.5 kg cart. What is their common speed immediately after the collision?
- A. 1.00 m/s
 - B. 5.00 m/s
 - C. 4.00 m/s
 - D. 2.00 m/s
8. A cart starts from rest and reaches 10 m/s in 2 s with constant acceleration. What is the magnitude of its acceleration?
- A. 12.0 m/s²
 - B. 5.0 m/s²
 - C. 2.5 m/s²
 - D. 20.0 m/s²
9. A ball rolls horizontally from a table 1.0 m high with speed 3.0 m/s. Neglect air resistance. Approximately how far from the table does it land?
- A. 0.3 m
 - B. 1.4 m
 - C. 2.7 m
 - D. 1.0 m
10. A velocity-time graph is a straight line from 2 m/s at $t = 0$ to 2 m/s at $t = 5$ s. What is the displacement during the interval?
- A. -1.0 m
 - B. 0.0 m
 - C. 12.5 m
 - D. 10.0 m

- 11.** A net horizontal force of 8 N acts on a 1.0 kg object. What is the object's acceleration?
- A. 0.12 m/s²
 - B. -1.8 m/s²
 - C. 8.0 m/s²
 - D. 10.0 m/s²
- 12.** A 1.5 kg block slides on a horizontal surface with coefficient of kinetic friction 0.35. What is the kinetic-friction force?
- A. 10.3 N
 - B. 14.7 N
 - C. 5.1 N
 - D. 0.52 N
- 13.** A 0.50 kg object moves in a horizontal circle of radius 0.8 m at speed 2.0 m/s. What is the required inward net force?
- A. 0.8 N
 - B. 1.2 N
 - C. 0.10 N
 - D. 2.5 N
- 14.** A spring with $k = 40 \text{ N/m}$ is stretched 0.08 m from equilibrium. Which best describes the spring force on the attached object?
- A. 3.2 N in the direction of displacement
 - B. 0.1 N opposite the displacement
 - C. 500.0 N opposite the displacement
 - D. 3.2 N opposite the displacement
- 15.** A 1.0 kg object starts from rest and drops through a vertical height of 0.8 m with negligible friction. What is its speed after the drop?
- A. 15.7 m/s
 - B. 4.0 m/s
 - C. 2.8 m/s
 - D. 7.8 m/s
- 16.** A constant force of 20 N pulls an object 3.0 m. The force makes an angle of 60 degrees with the displacement. How much work does the force do?
- A. 60.0 J
 - B. 30.0 J
 - C. 52.0 J
 - D. 6.7 J

17. A motor does 180 J of work in 4.0 s. What is its average power output?

- A. 0.022 W
- B. 45.0 W
- C. 22.5 W
- D. 720.0 W

18. A spring of constant 40 N/m is compressed by 0.10 m. How much elastic potential energy is stored?

- A. 4.00 J
- B. 0.40 J
- C. 2.00 J
- D. 0.20 J

19. A 1.0 kg cart moving at 2.0 m/s collides with and sticks to a stationary 2.0 kg cart. What is their common speed immediately after the collision?

- A. 0.33 m/s
- B. 1.33 m/s
- C. 0.67 m/s
- D. 2.00 m/s

20. A 0.50 kg ball changes velocity from -2.0 m/s to -1.0 m/s along the x-axis. What is the x-component of the impulse on the ball?

- A. 0.5 N s
- B. 2.0 N s
- C. -1.5 N s
- D. 0.5 J

- 21.** A constant force of 20 N acts for 0.10 s. What impulse is delivered?
- A. 200.0 N s
 - B. 20.1 N s
 - C. 2.0 N s
 - D. 1.0 N s
- 22.** A force of 15 N is applied at radius 0.30 m from a pivot, making 60 degrees with the radius. What is the torque magnitude about the pivot?
- A. 3.9 N m
 - B. 2.3 N m
 - C. 4.5 N m
 - D. 50.0 N m
- 23.** A rigid body with rotational inertia 0.50 kg m^2 experiences a net torque of 2.5 N m. What is its angular acceleration?
- A. 5.0 rad/s^2
 - B. 1.2 rad/s^2
 - C. 0.20 rad/s^2
 - D. 2.5 rad/s^2
- 24.** An object rolls without slipping down an incline at 15 degrees. Its rotational inertia is $I = 0.50MR^2$. What is its center-of-mass acceleration?
- A. 6.31 m/s^2
 - B. 1.69 m/s^2
 - C. 3.80 m/s^2
 - D. 2.54 m/s^2
- 25.** A wheel starts from rest with constant angular acceleration 3.0 rad/s^2 . What is its angular speed after 5.0 s?
- A. 15.0 rad/s
 - B. 0.6 rad/s
 - C. 37.5 rad/s
 - D. 75.0 rad/s
- 26.** A 0.40 kg mass oscillates on an ideal spring with $k = 25 \text{ N/m}$. What is the period?
- A. 0.13 s
 - B. 49.67 s
 - C. 0.79 s
 - D. 0.10 s
- 27.** An ideal spring-mass oscillator has spring constant 40 N/m and amplitude 0.15 m. What is the total mechanical energy?
- A. 6.00 J
 - B. 0.45 J
 - C. 3.00 J
 - D. 0.90 J

28. An ideal small-angle pendulum is moved to a planet where gravitational field strength is 0.49 times Earth's value. Its length is unchanged. What is the new period relative to its Earth period?

- A. 1.43 times the Earth period
- B. 2.04 times the Earth period
- C. 0.49 times the Earth period
- D. 0.70 times the Earth period

29. The distance from a planet's center to a satellite is increased from r to $2r$ while the planet mass stays fixed. How does the gravitational force magnitude change?

- A. twice as large
- B. one-fourth as large
- C. four times as large
- D. one-half as large

30. A 0.5 kg object starts from rest and drops through a vertical height of 1.0 m with negligible friction. What is its speed after the drop?

- A. 3.1 m/s
- B. 19.6 m/s
- C. 9.8 m/s
- D. 4.4 m/s

- 31.** A 0.40 kg object moves in a horizontal circle of radius 1.0 m at speed 2.0 m/s. What is the required inward net force?
- A. 0.10 N
 - B. 1.0 N
 - C. 0.8 N
 - D. 1.6 N
- 32.** A 0.10 kg mass oscillates on an ideal spring with $k = 40 \text{ N/m}$. What is the period?
- A. 0.05 s
 - B. 0.02 s
 - C. 125.66 s
 - D. 0.31 s
- 33.** A force of 15 N is applied at radius 0.50 m from a pivot, making 90 degrees with the radius. What is the torque magnitude about the pivot?
- A. 7.5 N m
 - B. 9.4 N m
 - C. 0.0 N m
 - D. 30.0 N m
- 34.** A rigid body with rotational inertia 0.30 kg m^2 experiences a net torque of 3.0 N m. What is its angular acceleration?
- A. 5.0 rad/s^2
 - B. 0.9 rad/s^2
 - C. 10.0 rad/s^2
 - D. 0.10 rad/s^2
- 35.** An ideal small-angle pendulum is moved to a planet where gravitational field strength is 0.49 times Earth's value. Its length is unchanged. What is the new period relative to its Earth period?
- A. 1.43 times the Earth period
 - B. 0.49 times the Earth period
 - C. 2.04 times the Earth period
 - D. 0.70 times the Earth period
- 36.** A 2.0 kg cart moving at 4.0 m/s collides with and sticks to a stationary 2.0 kg cart. What is their common speed immediately after the collision?
- A. 2.00 m/s
 - B. 1.00 m/s
 - C. 4.00 m/s
 - D. 5.00 m/s

37. A cart starts from rest and reaches 8 m/s in 4 s with constant acceleration. What is the magnitude of its acceleration?
- A. 12.0 m/s²
 - B. 1.0 m/s²
 - C. 32.0 m/s²
 - D. 2.0 m/s²
38. A ball rolls horizontally from a table 1.2 m high with speed 2.0 m/s. Neglect air resistance. Approximately how far from the table does it land?
- A. 2.0 m
 - B. 0.7 m
 - C. 1.0 m
 - D. 0.2 m
39. A velocity-time graph is a straight line from 6 m/s at $t = 0$ to -2 m/s at $t = 5$ s. What is the displacement during the interval?
- A. 40.0 m
 - B. -10.0 m
 - C. -1.6 m
 - D. 10.0 m
40. A net horizontal force of 18 N acts on a 1.5 kg object. What is the object's acceleration?
- A. 2.2 m/s²
 - B. 0.08 m/s²
 - C. 12.0 m/s²
 - D. 27.0 m/s²

41. A 2.0 kg block slides on a horizontal surface with coefficient of kinetic friction 0.30. What is the kinetic-friction force?
- A. 19.6 N
 - B. 5.9 N
 - C. 0.60 N
 - D. 11.8 N
42. A 0.40 kg object moves in a horizontal circle of radius 0.8 m at speed 5.0 m/s. What is the required inward net force?
- A. 1.6 N
 - B. 2.5 N
 - C. 12.5 N
 - D. 0.01 N
43. A spring with $k = 40 \text{ N/m}$ is stretched 0.05 m from equilibrium. Which best describes the spring force on the attached object?
- A. 800.0 N opposite the displacement
 - B. 2.0 N in the direction of displacement
 - C. 0.1 N opposite the displacement
 - D. 2.0 N opposite the displacement
44. A 1.0 kg object starts from rest and drops through a vertical height of 0.5 m with negligible friction. What is its speed after the drop?
- A. 2.2 m/s
 - B. 9.8 m/s
 - C. 3.1 m/s
 - D. 4.9 m/s
45. A constant force of 20 N pulls an object 2.0 m. The force makes an angle of 0 degrees with the displacement. How much work does the force do?
- A. 50.0 J
 - B. 40.0 J
 - C. 0.0 J
 - D. 10.0 J
46. An object moves at constant speed in a circle. Which TWO statements are correct? **Select TWO.**
- A. Its velocity is tangent to the path.
 - B. Its net force points toward the center.
 - C. Its acceleration is zero because speed is constant.
 - D. Its net force is tangent to the path.

47. A cart moves with constant positive acceleration. Which TWO statements must be true during any interval in which the acceleration remains constant? **Select TWO.**

- A. The velocity-time graph has constant slope.
- B. The acceleration-time graph is horizontal.
- C. The position-time graph must be a straight line.
- D. The speed must be increasing.

48. Two carts collide on a horizontal track with negligible external impulse. Which TWO statements are always true for the two-cart system? **Select TWO.**

- A. Total momentum is conserved.
- B. The center-of-mass velocity is constant.
- C. Total kinetic energy is conserved.
- D. Each cart has the same momentum magnitude before and after.

49. Which TWO changes can increase the magnitude of torque produced by a force about a fixed pivot? **Select TWO.**

- A. Increase the force magnitude.
- B. Increase the perpendicular lever arm.
- C. Move the force line of action through the pivot.
- D. Make the force more parallel to the radius vector.

50. For an ideal mass-spring oscillator, which TWO statements are correct? **Select TWO.**

- A. Speed is greatest at equilibrium.
- B. Acceleration points toward equilibrium.
- C. Acceleration is zero at maximum displacement.
- D. Spring potential energy is greatest at equilibrium.

SECTION II - Free Response

5 questions | 90 minutes | Show reasoning, equations, units, graphs, and experimental logic when requested.

Legacy paper format: two longer 12-point FRQs and three shorter 7-point FRQs, with mixed derivation, argumentation, graphing, and experimental design.

Question 1 - Short FRQ: Energy and vertical circular motion (7 points)

A. A block starts from rest at height $6R$ above a reference level and reaches the top of a circular loop at height $2R$. Friction is negligible. Draw an energy bar representation at the top of the loop relative to the release point.

B. Derive the speed at the top of the loop.

C. Determine the normal force at the top for a loop radius R and explain the inward-force direction.

Question 2 - Long FRQ: Spring constant experiment and oscillation graphs (12 points)

- A.** Using only several unknown-mass cylinders, a digital scale, a vertical spring and a stopwatch, design a procedure to determine the spring constant k dynamically.
- _____
- _____
- _____
- B.** State what graph should be linear and how its slope determines k .
- _____
- _____
- _____
- C.** A cart attached to the same spring oscillates horizontally. Given a velocity-time graph and a force-time graph, explain how to calculate a change in kinetic energy from velocity data and estimate impulse from force data.
- _____
- _____
- _____
- D.** Describe a consistency check between the force-time and velocity-time information.
- _____
- _____
- _____

Question 3 - Long FRQ: Hinged beam and rotational dynamics (12 points)

A. A uniform horizontal beam of mass M and length L is hinged to a wall. A string attached to the free end makes angle θ above the beam and holds it in equilibrium. Draw all forces on the beam.

B. Derive the string tension in terms of M , g and θ .

C. The string is cut. Derive the initial angular acceleration using $I = \frac{1}{3}ML^2$ for a uniform beam about one end.

D. Sketch and justify the qualitative angular-speed-versus-time behavior while the beam falls toward vertical.

Question 4 - Short FRQ: Pendulum and gravitation (7 points)

A. An ideal pendulum of length L has period T on Earth. On a planet with surface gravitational field $g/4$, determine the new period.

B. A spring-mass oscillator is transported to the same planet. Compare its period with its Earth period.

C. Explain why the two oscillators respond differently to the change in gravitational field.

Question 5 - Short FRQ: Elastic collision and center of mass (7 points)

A. Two carts collide elastically on a horizontal track with negligible external force. State the conservation laws that apply.

B. Sketch a qualitative center-of-mass position-versus-time graph through the collision.

C. Explain how the graph would differ, if at all, for a perfectly inelastic collision with the same initial total momentum and masses.

ANSWER KEY - Section I

1. C - Energy Conservation of energy: $mgh = \frac{1}{2}mv^2$, so $v = \sqrt{2gh} = 3.1$ m/s. Mass cancels.	2. B - Forces $F_c = mv^2/r = 4.0$ N.
3. A - Oscillations $T = 2\pi\sqrt{m/k} = 0.44$ s.	4. B - Rotation Torque magnitude is $\tau = rF \sin(\theta) = 5.0$ N m.
5. C - Rotation Rotational Newton second law: $\tau_{\text{net}} = I\alpha$, so $\alpha = \tau/I = 10.0$ rad/s ² .	6. A - Oscillations T is proportional to $1/\sqrt{g}$, so $T_{\text{new}}/T_E = 1/\sqrt{1.44} = 0.83$.
7. D - Momentum Momentum conservation gives $m_1 v_1 = (m_1 + m_2) v_f$, so $v_f = 2.00$ m/s.	8. B - Kinematics For constant acceleration, $a = \Delta v / \Delta t = 10/2 = 5.0$ m/s ² .
9. B - Kinematics Fall time is $\sqrt{2h/g} = 0.45$ s, so horizontal range is $v_x t = 1.4$ m.	10. D - Kinematics Displacement equals area under v-t graph: average velocity times time = $(2+2)/2 \times 5 = 10.0$ m.
11. C - Forces Newton second law gives $a = F_{\text{net}}/m = 8/1.0 = 8.0$ m/s ² .	12. C - Forces $F_k = \mu_k N = \mu_k mg = 0.35(1.5)(9.8) = 5.1$ N.
13. D - Forces $F_c = mv^2/r = 2.5$ N.	14. D - Forces Hooke law gives $F_s = -kx$. Magnitude is $40(0.08) = 3.2$ N and direction is toward equilibrium.
15. B - Energy Conservation of energy: $mgh = \frac{1}{2}mv^2$, so $v = \sqrt{2gh} = 4.0$ m/s. Mass cancels.	16. B - Energy $W = Fd \cos(\theta) = 20(3.0)\cos(60) = 30.0$ J.
17. B - Energy Average power is work divided by time: $P = W/t = 45.0$ W.	18. D - Energy $U_s = \frac{1}{2}kx^2 = 0.20$ J.
19. C - Momentum Momentum conservation gives $m_1 v_1 = (m_1 + m_2) v_f$, so $v_f = 0.67$ m/s.	20. A - Momentum Impulse equals change in momentum: $J_x = m(v_f - v_i) = 0.5$ N s.
21. C - Momentum The area under a force-time graph is impulse. For constant force, $J = F \Delta t = 2.0$ N s.	22. A - Rotation Torque magnitude is $\tau = rF \sin(\theta) = 3.9$ N m.
23. A - Rotation Rotational Newton second law: $\tau_{\text{net}} = I\alpha$, so $\alpha = \tau/I = 5.0$ rad/s ² .	24. B - Rotation For rolling without slipping, $a = g \sin(\theta)/(1 + \beta) = 1.69$ m/s ² .
25. A - Rotation $\omega = \omega_0 + \alpha t = 15.0$ rad/s.	26. C - Oscillations $T = 2\pi\sqrt{m/k} = 0.79$ s.
27. B - Oscillations At maximum displacement all energy is spring potential: $E = \frac{1}{2}kA^2 = 0.45$ J.	28. A - Oscillations T is proportional to $1/\sqrt{g}$, so $T_{\text{new}}/T_E = 1/\sqrt{0.49} = 1.43$.
29. B - Forces Gravitational force varies as $1/r^2$, so doubling r makes the force 1/4 as large.	30. D - Energy Conservation of energy: $mgh = \frac{1}{2}mv^2$, so $v = \sqrt{2gh} = 4.4$ m/s. Mass cancels.

31. D - Forces $F_c = mv^2/r = 1.6 \text{ N}$.	32. D - Oscillations $T = 2\pi \sqrt{m/k} = 0.31 \text{ s}$.
33. A - Rotation Torque magnitude is $\tau = rF \sin(\theta) = 7.5 \text{ N m}$.	34. C - Rotation Rotational Newton second law: $\tau_{\text{net}} = I \alpha$, so $\alpha = \tau/I = 10.0 \text{ rad/s}^2$.
35. A - Oscillations T is proportional to $1/\sqrt{g}$, so $T_{\text{new}}/T_E = 1/\sqrt{0.49} = 1.43$.	36. A - Momentum Momentum conservation gives $m_1 v_1 = (m_1 + m_2) v_f$, so $v_f = 2.00 \text{ m/s}$.
37. D - Kinematics For constant acceleration, $a = \Delta v / \Delta t = 8/4 = 2.0 \text{ m/s}^2$.	38. C - Kinematics Fall time is $\sqrt{2h/g} = 0.49 \text{ s}$, so horizontal range is $v_x t = 1.0 \text{ m}$.
39. D - Kinematics Displacement equals area under v-t graph: average velocity times time = $(6+2)/2 \times 5 = 10.0 \text{ m}$.	40. C - Forces Newton second law gives $a = F_{\text{net}}/m = 18/1.5 = 12.0 \text{ m/s}^2$.
41. B - Forces $F_k = \mu_k N = \mu_k mg = 0.30(2.0)(9.8) = 5.9 \text{ N}$.	42. C - Forces $F_c = mv^2/r = 12.5 \text{ N}$.
43. D - Forces Hooke law gives $F_s = -kx$. Magnitude is $40(0.05) = 2.0 \text{ N}$ and direction is toward equilibrium.	44. C - Energy Conservation of energy: $mgh = 1/2 mv^2$, so $v = \sqrt{2gh} = 3.1 \text{ m/s}$. Mass cancels.
45. B - Energy $W = Fd \cos(\theta) = 20(2.0)\cos(0) = 40.0 \text{ J}$.	46. A & B - Forces Circular motion changes velocity direction, requiring inward acceleration and net force; velocity remains tangent.
47. A & B - Kinematics Constant acceleration means a horizontal a-t graph and a v-t graph with constant slope. Speed need not increase if velocity is initially opposite the acceleration.	48. A & B - Momentum Negligible external impulse conserves total momentum, so the center-of-mass velocity is constant. Kinetic energy depends on collision type.
49. A & B - Rotation Torque magnitude is $rF \sin(\theta)$, so increasing F or the perpendicular lever arm increases torque.	50. A & B - Oscillations In SHM speed is maximum at equilibrium and acceleration is restoring, directed toward equilibrium.

SCORING GUIDE - Section II

This compact rubric emphasizes the evidence a strong AP-style response should contain. Equivalent correct reasoning should receive credit.

Question 1 - Short FRQ: Energy and vertical circular motion - 7 points

3 points: At the top, gravitational energy corresponds to $2R$ and remaining energy is kinetic, consistent with total at $6R$.

2 points: $mg(6R) = mg(2R) + 1/2 mv^2$ gives $v = \sqrt{8gR}$.

2 points: At top, $mg + N = mv^2/R = 8mg$, so $N = 7mg$ toward the center.

Question 2 - Long FRQ: Spring constant experiment and oscillation graphs - 12 points

3 points: Measure mass and period for several masses, timing multiple cycles per trial.

3 points: Plot T^2 versus m ; slope = $4\pi^2/k$, so $k = 4\pi^2/\text{slope}$.

3 points: $\Delta K = 1/2 m(v_f^2 - v_i^2)$; impulse is area under F-t curve.

3 points: Compare impulse with $m \Delta v$ from velocity data.

Question 3 - Long FRQ: Hinged beam and rotational dynamics - 12 points

3 points: Includes weight at center, hinge force at pivot, and string tension at free end.

3 points: Torque balance: $TL \sin(\theta) = Mg(L/2)$, so $T = Mg/[2 \sin(\theta)]$.

3 points: Initial torque $MgL/2 = I \alpha$; $\alpha = 3g/(2L)$.

3 points: Angular speed increases, but angular acceleration decreases as gravitational torque decreases toward vertical.

Question 4 - Short FRQ: Pendulum and gravitation - 7 points

3 points: Pendulum period doubles because T is proportional to $1/\sqrt{g}$.

2 points: Ideal horizontal spring-mass period is unchanged: $2\pi \sqrt{m/k}$.

2 points: Pendulum restoring acceleration depends on g ; ideal spring restoring force depends on k and displacement, not g .

Question 5 - Short FRQ: Elastic collision and center of mass - 7 points

3 points: Total momentum and total kinetic energy are conserved for an elastic collision.

2 points: Center-of-mass position is a straight line with constant slope if external force is negligible.

2 points: It would not differ in center-of-mass motion; collision type affects internal relative motion and kinetic energy, not total center-of-mass velocity.

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