AP Physics 1: Kinematics Exam Questions with Detailed Solutions

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1. A car accelerates uniformly from rest to a velocity of 25 m/s in 5 seconds. What is its acceleration?

Formula:

$a = \frac{v_f - v_i}{t}$

Given:

$v_i = 0$ m/s, $v_f = 25$ m/s, $t = 5$ s

Solution:

$a = \frac{25-0}{5} = \frac{25}{5} = 5\ m/s^2$

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2. A ball is dropped from a height of 50 meters. How long does it take to reach the ground?

Formula:

$t = \sqrt{\frac{2h}{g}}$

Given:

$h = 50$ m, $g = 9.81$ m/s²

Solution:

$t = \sqrt{\frac{2(50)}{9.81}}\ t = \sqrt{\frac{100}{9.81}} = \sqrt{10.19} = 3.19\ s$

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3. A car moving at 20 m/s slows down uniformly to a stop in 4 seconds. What is its acceleration?

Formula:

$a = \frac{v_f - v_i}{t}$

Given:

$v_i = 20$ m/s, $v_f = 0$ m/s, $t = 4$ s

Solution:

$a = \frac{0-20}{4} = \frac{-20}{4} = -5\ m/s^2$

(The negative sign indicates deceleration.)

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4. A projectile is launched with an initial velocity of 30 m/s at an angle of 45°. What is the time of flight?

Formula:

$T = \frac{2v_i sin\theta}{g}$

Given:

$v_i = 30$ m/s, $\theta = 45^\circ$, $g = 9.81$ m/s²

Solution:

$T = \frac{2(30)sin45^\circ}{9.81}\ T = \frac{60 \times 0.707}{9.81} = \frac{42.42}{9.81} = 4.33\ s$

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5. What is the displacement of a car that moves with an initial velocity of 10 m/s, accelerates at 2 m/s² for 6 seconds?

Formula:

$s = v_i t + \frac{1}{2} a t^2$

Given:

$v_i = 10$ m/s, $a = 2$ m/s², $t = 6$ s

Solution:

$s = (10)(6) + \frac{1}{2}(2)\left(6^2\right)$ $s = 60 + \frac{1}{2}(2)(36)$ $s = 60 + 36 = 96\, m$

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6. A runner starts from rest and reaches a speed of 8 m/s in 4 seconds. What is the acceleration?

Formula:

$a = \frac{v_f - v_i}{t}$

Given:

$v_i = 0$ m/s, $v_f = 8$ m/s, $t = 4$ s

Solution:

$a = \frac{8-0}{4} = \frac{8}{4} = 2\, m/s^2$

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7. A rock is thrown straight up with an initial velocity of 20 m/s. How high will it go before stopping?

Formula:

$h = \frac{v_i^2}{2g}$

Given:

$v_i = 20$ m/s, $g = 9.81$ m/s²

Solution:

$h = \frac{20^2}{2(9.81)}$ $h = \frac{400}{19.62} = 20.4\ m$

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8. A cyclist moves with an initial speed of 5 m/s and accelerates at 1.5 m/s² for 10 seconds. What is the final velocity?

Formula:

$v_f = v_i + at$

Given:

$v_i = 5$ m/s, $a = 1.5$ m/s², $t = 10$ s

Solution:

$v_f = 5 + (1.5)(10)$ $v_f = 5 + 15 = 20\ m/s$

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9. A car covers 100 m in 5 seconds, starting from rest with uniform acceleration. What is the acceleration?

Formula:

$s = v_i t + \frac{1}{2}at^2$

Given:

$v_i = 0$ m/s, $s = 100$ m, $t = 5$ s

Solution:

$100 = 0 + \frac{1}{2}a\left(5^2\right)$ $100 = \frac{1}{2}a(25)$ $a = \frac{200}{25} = 8\ m/s^2$

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10. A plane needs to reach 80 m/s to take off and has a runway of 400 m. What minimum acceleration is required?

Formula:

$v_f^2 = v_i^2 + 2as$

Given:

$v_i = 0$ m/s, $v_f = 80$ m/s, $s = 400$ m

Solution:

$80^2 = 0 + 2a(400)$ $6400 = 800a$ $a = \frac{6400}{800} = 8\ m/s^2$

Here are the **detailed solutions** for questions 11 to 20.

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11. Two cars start from the same point, one moving with a constant velocity of 20 m/s and the other accelerating at 2 m/s² from rest. When will they meet?

Step 1: Use distance formulas

- Distance covered by the first car moving at constant speed: $s_1 = vt$
- Distance covered by the second car starting from rest with acceleration: $s_2 = v_i t + \frac{1}{2}at^2$

Step 2: Given values

- First car: $v = 20$ m/s
- Second car: $v_i = 0$, $a = 2$ m/s²

Since they meet at the same distance:

$20t = \frac{1}{2}(2)t^2$ $20t = t^2$ $t = 20\ s$

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12. A ball is thrown horizontally from a 45m high cliff with a speed of 10 m/s. How long does it take to hit the ground?

Step 1: Use free fall equation

$t = \sqrt{\frac{2h}{g}}$

Step 2: Given values

- $h = 45$ m
- $g = 9.81$ m/s²

$t = \sqrt{\frac{2(45)}{9.81}}\ t = \sqrt{9.17} = 3.03\ s$

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13. A boat crosses a river 200m wide with a current of 3 m/s. If the boat moves at 4 m/s relative to the water, what is the time taken to cross?

Step 1: Use time equation

$t = \frac{width}{boat\ speed\ perpendicular\ to\ current}$

Step 2: Given values

- $width = 200$ m
- $boat\ speed = 4$ m/s

$t = \frac{200}{4} = 50\ s$

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14. A train starts from rest and accelerates uniformly at 1.5 m/s². How long does it take to travel 200m?

Step 1: Use motion equation

$s = v_i t + \frac{1}{2}at^2$

Step 2: Given values

- $v_i = 0$ m/s

- $a = 1.5$ m/s²
- $s = 200$ m

$200 = 0 + \frac{1}{2}(1.5)t^2$ $200 = 0.75t^2$ $t^2 = \frac{200}{0.75} = 266.67$ $t = 16.33\ s$

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16. A ball is thrown upwards with a velocity of 15 m/s. How long will it take to reach its maximum height?

Step 1: Use time equation

$t = \frac{v_i}{g}$

Step 2: Given values

- $v_i = 15$ m/s
- $g = 9.81$ m/s²

$t = \frac{15}{9.81} = 1.53\ s$

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17. A rocket moves vertically upward with an acceleration of 20 m/s². What is its velocity after 8 seconds?

Step 1: Use velocity equation

$v_f = v_i + at$

Step 2: Given values

- $v_i = 0$ m/s
- $a = 20$ m/s²
- $t = 8$ s

$v_f = 0 + (20)(8) = 160\ m/s$

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18. A car moving at 30 m/s suddenly applies brakes and stops in 5 seconds. What is the stopping distance?

Step 1: Use motion equation

$s = v_i t + \frac{1}{2} a t^2$

Step 2: Given values

- $v_i = 30$ m/s
- $v_f = 0$
- $t = 5$ s

Find acceleration using:

$a = \frac{v_f - v_i}{t} = \frac{0-30}{5} = -6\ m/s^2$

Now find distance:

$s = (30)(5) + \frac{1}{2}(-6)\left(5^2\right)\ s = 150 - 75 = 75\ m$

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19. A cyclist moving with a speed of 12 m/s decelerates at 2 m/s². How far does it travel before coming to rest?

Step 1: Use motion equation

$v_f^2 = v_i^2 + 2as$

Step 2: Given values

- $v_i = 12$ m/s
- $v_f = 0$
- $a = -2$ m/s²

$0 = 12^2 + 2(-2)s\ 0 = 144 - 4s\ s = 36\ m$

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20. A stone is dropped into a well, and the sound of the splash is heard 3 seconds later. Find the depth of the well.

Step 1: Define time equation

$t_{total} = t_{fall} + t_{sound}$

- $t_{fall} = \sqrt{\frac{2d}{g}}$
- $t_{sound} = \frac{d}{v_{sound}}$

Where:

- $g = 9.81$ m/s²
- $v_{sound} = 343$ m/s
- $t_{total} = 3$ s

Step 2: Solve for depth d

Using numerical approximation:

$d = 41.2\ m$

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21. A bullet is fired straight up with an initial velocity of 50 m/s. How long does it take to reach the highest point?

Formula:

$t = \frac{v_i}{g}$

Given:
$v_i = 50$ m/s, $g = 9.81$ m/s²

Solution:

$t = \frac{50}{9.81} = 5.1\ s$

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22. A child throws a ball upward with an initial speed of 10 m/s. What is the total time for the ball to return to the child's hand?

Formula:

$T = 2 \times \frac{v_i}{g}$

Given:

$v_i = 10$ m/s, $g = 9.81$ m/s²

Solution:

$T = 2 \times \frac{10}{9.81}\ T = 2.04\ s$

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23. A runner accelerates uniformly from rest at 3 m/s². How far has the runner traveled after 4 seconds?

Formula:

$s = v_i t + \frac{1}{2} a t^2$

Given:

$v_i = 0$, $a = 3$ m/s², $t = 4$ s

Solution:

$s = 0 + \frac{1}{2}(3)\left(4^2\right)\ s = \frac{1}{2}(3)(16)\ s = 24\ m$

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24. A bird flies 100 m east, then 75 m north. What is the bird's displacement?

Formula:

$d = \sqrt{x^2 + y^2}$

Given:

$x = 100$ m, $y = 75$ m

Solution:

$d = \sqrt{100^2 + 75^2}\ d = \sqrt{10000 + 5625}\ d = \sqrt{15625} = 125\ m$

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25. A jet accelerates from 100 m/s to 250 m/s over 5 seconds. What is its acceleration?

Formula:

$a = \frac{v_f - v_i}{t}$

Given:

$v_i = 100$ m/s, $v_f = 250$ m/s, $t = 5$ s

Solution:

$a = \frac{250-100}{5} = \frac{150}{5} = 30\ m/s^2$

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26. A train decelerates from 40 m/s to rest in 10 seconds. How far does it travel during this time?

Formula:

$s = v_i t + \frac{1}{2}at^2$

Given:

$v_i = 40$ m/s, $v_f = 0$, $t = 10$ s

Find acceleration:

$a = \frac{0-40}{10} = -4\ m/s^2\ s = (40)(10) + \frac{1}{2}(-4)\left(10^2\right)\ s = 400 - 200 = 200\ m$

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27. A person walks 3 km east, then 4 km north. What is the total displacement?

Formula:

$d = \sqrt{x^2 + y^2}$

Given:
$x = 3$ km, $y = 4$ km

Solution:

$d = \sqrt{3^2 + 4^2}\ d = \sqrt{9 + 16}\ d = \sqrt{25} = 5\ km$

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28. A motorbike moving at 15 m/s accelerates at 3 m/s² for 4 seconds. What is the final velocity?

Formula:

$v_f = v_i + at$

Given:
$v_i = 15$ m/s, $a = 3$ m/s², $t = 4$ s

Solution:

$v_f = 15 + (3)(4)\ v_f = 15 + 12 = 27\ m/s$

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29. A stone is thrown downward from a 30m high building with an initial velocity of 5 m/s. How long does it take to hit the ground?

Formula:

$s = v_i t + \frac{1}{2} g t^2$

Given:
$s = 30$ m, $v_i = 5$ m/s, $g = 9.81$ m/s²

Solution (Using quadratic formula):

$5t + \frac{1}{2}(9.81)t^2 = 30$

Solving numerically:

$t = 2.13\ s$

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30. A tennis ball is hit at 20 m/s at a 30° angle. How long is it in the air?

Formula:

$T = \frac{2v_i sin\theta}{g}$

Given:

$v_i = 20$ m/s, $\theta = 30^\circ$, $g = 9.81$ m/s²

Solution:

$T = \frac{2(20)sin30^\circ}{9.81}\ T = \frac{40 \times 0.5}{9.81} = 2.04\ s$

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31. A spaceship moves 5000 km in 10 seconds. What is its average velocity?

Formula:

$v = \frac{distance}{time}$

Given:

$d = 5000$ km, $t = 10$ s

Solution:

$v = \frac{5000}{10} = 500\ km/s$

Here are the **detailed solutions** for the remaining questions **32 to 40**.

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32. A satellite orbits the Earth at a constant speed of 8000 m/s. What is its acceleration?

Step 1: Use circular motion formula

$a = \frac{v^2}{r}$

Acceleration depends on the **radius** of the orbit, which is not given in the problem. Assuming the satellite is in low Earth orbit, a typical altitude is **400 km** above Earth's surface. The Earth's radius is approximately **6370 km**, so:

$r = 6370 + 400 = 6770\ km = 6.77 \times 10^6\ m$

Step 2: Given values

- $v = 8000$ m/s
- $r = 6.77 \times 10^6$ m

Solution:

$a = \frac{(8000)^2}{6.77 \times 10^6}\ a = \frac{64000000}{6.77 \times 10^6}\ a = 9.44\ m/s^2$

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33. A skier accelerates at 2.5 m/s² down a slope for 6 seconds. What is the final velocity?

Step 1: Use velocity formula

$v_f = v_i + at$

Step 2: Given values

- $v_i = 0$ (starts from rest)
- $a = 2.5$ m/s²
- $t = 6$ s

Solution:

$v_f = 0 + (2.5)(6)\ v_f = 15\ m/s$

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34. A parachutist falls freely for 3 seconds before opening the parachute. What is the velocity before opening?

Step 1: Use velocity formula

$v = gt$

Step 2: Given values

- $g = 9.81$ m/s²
- $t = 3$ s

Solution:

$v = (9.81)(3)\ v = 29.43\ m/s$

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35. A cyclist rides at 5 m/s, then accelerates at 1 m/s² for 10 seconds. How far does the cyclist travel?

Step 1: Use motion formula

$s = v_i t + \frac{1}{2}at^2$

Step 2: Given values

- $v_i = 5$ m/s
- $a = 1$ m/s²
- $t = 10$ s

Solution:

$s = (5)(10) + \frac{1}{2}(1)\left(10^2\right)\ s = 50 + \frac{1}{2}(100)\ s = 50 + 50 = 100\ m$

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36. A bus moving at 20 m/s decelerates at 4 m/s² to a stop. What is the stopping distance?

Step 1: Use motion equation

$s = v_i t + \frac{1}{2}at^2$

Step 2: Find time using velocity equation

$t = \frac{v_f - v_i}{a} = \frac{0-20}{-4} = 5\ s$

Step 3: Solve for s

$s = (20)(5) + \frac{1}{2}(-4)\left(5^2\right)\ s = 100 - 50 = 50\ m$

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37. A sprinter running at 8 m/s slows down to rest in 2 seconds. What is the deceleration?

Step 1: Use acceleration formula

$a = \frac{v_f - v_i}{t}$

Step 2: Given values

- $v_i = 8$ m/s
- $v_f = 0$
- $t = 2$ s

Solution:

$a = \frac{0-8}{2}\ a = -4\ m/s^2$

(The negative sign indicates deceleration.)

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38. A car covers a distance of 500m in 20 seconds with uniform acceleration. Find the acceleration.

Step 1: Use motion formula

$s = v_i t + \frac{1}{2}at^2$

Step 2: Given values

- $v_i = 0$ (starts from rest)
- $s = 500$ m
- $t = 20$ s

***Solution*:**

$500 = 0 + \frac{1}{2}a\left(20^2\right)\ 500 = \frac{1}{2}a(400)\ a = \frac{1000}{400} = 2.5\ m/s^2$

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39. A projectile reaches a maximum height of 80m. What was its initial vertical velocity?

Step 1: Use height formula

$h = \frac{v_i^2}{2g}$

***Step 2*: Given values**

- $h = 80$ m
- $g = 9.81$ m/s²

***Solution*:**

$80 = \frac{v_i^2}{2(9.81)}\ 80 \times 19.62 = v_i^2\ v_i^2 = 1569.6\ v_i = \sqrt{1569.6} = 39.6\ m/s$

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40. A car accelerates from 0 to 30 m/s in 10 seconds. How far does it travel?

***Step 1*: Use motion formula**

$s = v_i t + \frac{1}{2}at^2$

***Step 2*: Find acceleration**

$a = \frac{v_f - v_i}{t} = \frac{30-0}{10} = 3\ m/s^2$

***Step 3*: Solve for s**

$s = 0 + \frac{1}{2}(3)\left(10^2\right)\ s = \frac{1}{2}(3)(100)\ s = 150\ m$
