

Grade 12 Physics Kinematics Key

First Name:	KEY	
Last Name:		

Directions:

- Please answer to 2 decimal points
- \bullet The test is designed to be completed in 75 minutes

For grading use only

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Points:	7	7	6	10	5	5	10	10	10	10	80
Score:											

Questions

1. (1 point) A car accelerates uniformly from rest to a speed of 25 m/s in 10 seconds. What is the car's acceleration?

- A. 1.5 m/s^2
- B. 2.5 m/s^2
- C. 3.5 m/s^2
- D. 4.5 m/s^2

2. (1 point) An object is thrown vertically upward with an initial velocity of 20 m/s. What is its velocity after 3 seconds? (Assume $g = 9.8 \text{ m/s}^2$.)

- A. 10.6 m/s
- B. 0 m/s
- C. -9.4 m/s
- D. -19.4 m/s

3. (1 point) A ball is dropped from a height of 80 m. How long does it take to hit the ground? (Assume $g = 9.8 \text{ m/s}^2$.)

- **A.** 4 s
- B. 5 s
- C. 6 s
- D. 7 s

4. (1 point) A car traveling at 20 m/s comes to a stop in 4 seconds. What is the magnitude of its acceleration?

- A. 4 m/s^2
- B. 5 m/s^2
- C. 6 m/s^2
- D. 7 m/s^2

5. (1 point) An object moves with a constant velocity of 15 m/s for 10 seconds. What is its displacement?

- A. 100 m
- B. 125 m
- C. 150 m
- D. 200 m

6. (1 point) A ball is thrown upward with a velocity of 30 m/s. How long does it take to reach the maximum height? (Assume $g = 9.8 \text{ m/s}^2$.)

- A. 2.5 s
- B. 3.0 s
- C. 3.5 s
- D. 4.0 s

7. (1 point) A cyclist accelerates uniformly from rest to a velocity of 10 m/s in 5 seconds. What is the total distance covered during this time?

- A. 15 m
- B. 20 m

- C. 25 m
- D. 30 m

8. (1 point) An object accelerates uniformly at 4 m/s^2 for 6 seconds. If it starts from rest, what is its final velocity?

- A. 20 m/s
- B. 24 m/s
- C. 28 m/s
- D. 32 m/s
- 9. (1 point) A rock is thrown horizontally at 15 m/s from a cliff that is 45 m high. How long does it take for the rock to hit the ground? (Assume $g=9.8~\mathrm{m/s^2}$.)
 - A. 2.5 s
 - B. 3.0 s
 - C. 3.5 s
 - D. 4.0 s
- 10. (1 point) A ball is thrown downward with an initial velocity of 5 m/s. How far does it fall in 3 seconds? (Assume $g = 9.8 \text{ m/s}^2$.)
 - A. 35.4 m
 - B. 44.1 m
 - C. 53.4 m
 - D. 62.1 m
- 11. (1 point) A ball is dropped from rest, and after falling for 3 seconds, its velocity is:
 - A. 9.8 m/s
 - B. 19.6 m/s
 - C. 29.4 m/s
 - D. 39.2 m/s
- 12. (1 point) A train is traveling at 40 m/s and slows down uniformly to 20 m/s over 10 seconds. What is the distance traveled during this time?
 - A. 100 m
 - B. 200 m
 - C. 300 m
 - D. 400 m
- 13. (1 point) A projectile is launched at an angle of 45° with an initial velocity of 50 m/s. What is the total time of flight? (Assume $g = 9.8 \text{ m/s}^2$.)
 - A. 7.1 s
 - B. 8.2 s
 - $C.\ 9.3\ s$
 - D. 10.2 s
- 14. (1 point) A car is traveling at 30 m/s and accelerates uniformly at 3 m/s². How long does it take to reach a velocity of 60 m/s?
 - A. 5 s

- B. 10 s
- C. 15 s
- D. 20 s

15. (1 point) An object is thrown vertically upward with an initial velocity of 15 m/s. What is its maximum height? (Assume $g = 9.8 \text{ m/s}^2$.)

- A. 8.6 m
- B. 10.2 m
- C. 11.5 m
- D. 12.8 m

16. (1 point) A car accelerates uniformly from 10 m/s to 30 m/s over a distance of 100 m. What is the car's acceleration?

- A. 2 m/s^2
- B. 3 m/s^2
- C. 4 m/s^2
- D. 5 m/s^2

17. (1 point) An object is projected horizontally from a height of 80 m with a velocity of 20 m/s. How far does it travel horizontally before hitting the ground? (Assume $g = 9.8 \text{ m/s}^2$.)

- A. 80 m
- B. 100 m
- C. 120 m
- D. 160 m

18. (1 point) A ball is thrown downward with an initial velocity of 10 m/s. After 4 seconds, its velocity is:

- A. 29.8 m/s
- B. 39.2 m/s
- C. 49.6 m/s
- D. 59.0 m/s

19. (1 point) A cyclist travels 20 m at 4 m/s, then another 30 m at 6 m/s. What is their average velocity?

- A. 4.8 m/s
- B. 5.0 m/s
- C. 5.2 m/s
- D. 5.4 m/s

20. (1 point) A rocket accelerates from rest at 10 m/s² for 12 seconds. What is its final velocity?

- A. 100 m/s
- B. 110 m/s
- C. 120 m/s
- D. 130 m/s

Short Answer

21. (5 points) Derive the kinematic equation $v^2 = u^2 + 2as$ using basic definitions of acceleration and displacement.?

Solution: To derive the equation $v^2 = u^2 + 2as$, we start with the following basic kinematic definitions:

• Acceleration (a) is defined as the rate of change of velocity:

$$a = \frac{v-u}{t}, \quad where uis the initial velocity, visithe final velocity, and tis the time.$$

Rearranging, we get:

$$v = u + at$$
. (Equation 1)

• Displacement (s) is given by:

$$s = ut + \frac{1}{2}at^2$$
. (Equation 2)

Substitute $t = \frac{v-u}{a}$ (from Equation 1) into Equation 2:

$$s = u \left(\frac{v - u}{a}\right) + \frac{1}{2}a \left(\frac{v - u}{a}\right)^2.$$

Simplify each term:

$$s = \frac{u(v-u)}{a} + \frac{1}{2}a\frac{(v-u)^2}{a^2}.$$
$$s = \frac{u(v-u)}{a} + \frac{(v-u)^2}{2a}.$$

Combine the terms under a common denominator:

$$s = \frac{2u(v-u) + (v-u)^2}{2a}.$$

Expand and simplify the numerator:

$$s = \frac{v^2 - u^2}{2a}.$$

Finally, rearrange to isolate v^2 :

$$v^2 = u^2 + 2as.$$

- 22. A train moves with a constant acceleration of 2 m/s² for 15 seconds. If it starts from rest, calculate:
 - (a) (2 points) The acceleration
 - (b) (3 points) The distance traveled during this time.

Solution: Given:

• Acceleration, $a = 2 \,\mathrm{m/s^2}$,

- Time, $t = 15 \, \text{s}$,
- Initial velocity, $u = 0 \,\mathrm{m/s}$.
- (a) The acceleration is already given as:

$$a = 2 \,\mathrm{m/s^2}$$
.

(b) The distance traveled (s) can be calculated using the equation:

$$s = ut + \frac{1}{2}at^2.$$

Substitute the given values:

$$s = (0)(15) + \frac{1}{2}(2)(15)^{2},$$

$$s = 0 + \frac{1}{2}(2)(225),$$

$$s = 225 \,\mathrm{m}.$$

Final answers:

- (a) The acceleration is $2 \,\mathrm{m/s^2}$.
- (b) The distance traveled is 225 m.
- 23. A rocket is launched vertically upward with an initial velocity of 50 m/s. Calculate:
 - (a) (2 points) The maximum height it reaches.
 - (b) (3 points) The total time it takes to return to the ground.

Solution: Given:

- Initial velocity, $u = 50 \,\mathrm{m/s}$,
- Acceleration due to gravity, $a = -9.8 \,\mathrm{m/s^2}$.
- (a) To calculate the maximum height (h), we use the kinematic equation:

$$v^2 = u^2 + 2as.$$

where $v = 0 \,\mathrm{m/s}$ at the maximum height.

Substitute the values:

$$0 = (50)^{2} + 2(-9.8)h,$$

$$0 = 2500 - 19.6h,$$

$$h = \frac{2500}{19.6} \approx 127.55 \,\mathrm{m}.$$

(b) To calculate the total time (t) it takes to return to the ground, we first find the time to reach the maximum height:

$$v = u + at$$
.

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Substitute the values:

$$0 = 50 + (-9.8)t$$

$$t = \frac{50}{9.8} \approx 5.10 \,\mathrm{s}.$$

The total time to return to the ground is twice the time to reach the maximum height:

$$t_{total} = 2 \times 5.10 \approx 10.20 \,\mathrm{s}.$$

Final answers:

- (a) The maximum height is approximately 127.55 m.
- (b) The total time to return to the ground is approximately 10.20 s.
- 24. Two cars start from rest at the same point. Car A accelerates uniformly at 3 m/s², while Car B accelerates uniformly at 2 m/s². Calculate:
 - (a) (2 points) The time it takes for Car A to be 30 m ahead of Car B.
 - (b) (3 points) The distance covered by each car at this time.

Solution: Given:

- Acceleration of Car A, $a_A = 3 \,\mathrm{m/s^2}$,
- Acceleration of Car B, $a_B = 2 \,\mathrm{m/s^2}$,
- Both cars start from rest $(u_A = u_B = 0 \,\mathrm{m/s})$.
- (a) To find the time (t) it takes for Car A to be 30 m ahead of Car B, we calculate the displacement of each car using:

$$s = ut + \frac{1}{2}at^2.$$

The displacement of Car A is:

$$s_A = \frac{1}{2}a_A t^2 = \frac{1}{2}(3)t^2 = 1.5t^2.$$

The displacement of Car B is:

$$s_B = \frac{1}{2}a_B t^2 = \frac{1}{2}(2)t^2 = t^2.$$

The condition is:

$$s_A - s_B = 30,$$

 $1.5t^2 - t^2 = 30,$
 $0.5t^2 = 30.$

$$t^2 = 60t = \sqrt{60} \approx 7.75 \,\mathrm{s}.$$

(b) To find the distance covered by each car at this time:

$$s_A = 1.5t^2 = 1.5(60) = 90 \,\mathrm{m},$$

$$s_B = t^2 = 60 \,\mathrm{m}.$$

Final answers:

- (a) The time it takes for Car A to be 30 m ahead of Car B is approximately 7.75 s.
- (b) The distance covered by Car A is 90 m, and by Car B is 60 m.
- 25. A ball is thrown vertically upward with an initial velocity of 25 m/s. After 2 seconds, another ball is thrown upward with the same velocity. Determine:
 - (a) (5 points) The time at which the two balls meet.
 - (b) (5 points) The height at which they meet.

Solution: Given:

- Initial velocity of both balls, $u = 25 \,\mathrm{m/s}$,
- Acceleration due to gravity, $a = -9.8 \,\mathrm{m/s^2}$,
- Second ball is thrown t = 2s after the first ball.

Solution:

(a) Let the time after the first ball is thrown at which they meet be t_1 (for the first ball).

For the first ball, its position y_1 is given by:

$$y_1 = ut_1 + \frac{1}{2}at_1^2.$$

Substituting the known values:

$$y_1 = 25t_1 - 4.9t_1^2$$
.

For the second ball, let its position y_2 be expressed relative to the time it was thrown. It is thrown 2 seconds after the first ball, so its time of motion is $t_1 - 2$. Its position is:

$$y_2 = u(t_1 - 2) + \frac{1}{2}a(t_1 - 2)^2.$$

Substituting the known values:

$$y_2 = 25(t_1 - 2) - 4.9(t_1 - 2)^2$$
.

The balls meet when $y_1 = y_2$:

$$25t_1 - 4.9t_1^2 = 25(t_1 - 2) - 4.9(t_1 - 2)^2.$$

Expanding and simplifying:

$$25t_1 - 4.9t_1^2 = 25t_1 - 50 - 4.9(t_1^2 - 4t_1 + 4).$$

$$25t_1 - 4.9t_1^2 = 25t_1 - 50 - 4.9t_1^2 + 19.6t_1 - 19.6.$$

$$0 = -50 - 19.6 + 19.6t_1.$$

$$19.6t_1 = 69.6t_1 = \frac{69.6}{19.6} \approx 3.55 \text{ s.}$$

The second ball's time of motion is:

$$t_2 = t_1 - 2 = 3.55 - 2 = 1.55 \,\mathrm{s}.$$

(b) To find the height at which they meet, substitute $t_1 = 3.55\,\mathrm{s}$ into the equation for y_1 :

$$y_1 = 25(3.55) - 4.9(3.55)^2$$
.

$$y_1 = 88.75 - 61.63 \approx 27.12 \,\mathrm{m}.$$

Final answers:

- (a) The two balls meet at approximately $t = 3.55 \,\mathrm{s}$ after the first ball is thrown.
- (b) The height at which they meet is approximately 27.12 m.
- 26. A cyclist starts from rest and accelerates uniformly at a rate of 1.5 m/s^2 for 12 seconds. She then maintains a constant velocity for 20 seconds before decelerating uniformly to rest in 8 seconds.
 - (a) (3 points) Draw a velocity-time graph for the motion.
 - (b) (3 points) Calculate the total distance traveled.
 - (c) (4 points) Calculate the average velocity for the entire trip.

Solution: Given:

- Acceleration $a_1 = 1.5 \,\mathrm{m/s^2}$,
- Time of acceleration $t_1 = 12 \,\mathrm{s}$,
- Constant velocity time $t_2 = 20 \,\mathrm{s}$,
- Deceleration time $t_3 = 8 \,\mathrm{s}$.

Solution:

(a) The velocity-time graph can be drawn as follows: The cyclist accelerates uniformly for 12 seconds, reaching a velocity:

$$v_{max} = a_1 \cdot t_1 = 1.5 \cdot 12 = 18 \,\mathrm{m/s}.$$

She then maintains this constant velocity for 20 seconds, before decelerating uniformly to rest over 8 seconds.

The graph consists of three segments:

- A linearly increasing segment from 0 to 18 m/s over 12 s,
- A horizontal segment at 18 m/s for 20 s,
- A linearly decreasing segment from 18 m/s to 0 over 8 s.

(b) The total distance traveled is the area under the velocity-time graph. The graph forms a trapezoid:

Total distance = Area of trapezoid.

$$Distance = \frac{1}{2} \cdot (Base_1 + Base_2) \cdot Height.$$

For the three segments:

 $Distance during acceleration = \frac{1}{2} \cdot 12 \cdot 18 = 108 \, \mathrm{m}.$

 $Distance during constant velocity = 18 \cdot 20 = 360 \, \mathrm{m}.$

$$Distance during deceleration = \frac{1}{2} \cdot 8 \cdot 18 = 72 \, \mathrm{m}.$$

Total distance:

$$Total distance = 108 + 360 + 72 = 540 \,\mathrm{m}.$$

(c) To find the average velocity, use:

$$v_{avg} = \frac{Total distance}{Total time}.$$

$$Total time = 12 + 20 + 8 = 40 \text{ s.}$$

$$v_{avg} = \frac{540}{40} = 13.5 \,\text{m/s}.$$

Final answers:

- (a) The velocity-time graph consists of a linear increase, a constant segment, and a linear decrease.
- (b) The total distance traveled is 540 m.
- (c) The average velocity for the entire trip is 13.5 m/s.

27. A ball is dropped from a height of 200 m. At the same instant, another ball is thrown upward from the ground with an initial velocity of 50 m/s. Determine:

- (a) (3 points) The time at which the two balls meet.
- (b) (4 points) The height at which they meet.
- (c) (3 points) The velocities of both balls at the point of meeting.

Solution: (a) The time at which the two balls meet:

Using the equations of motion for the two balls: For the first ball (dropped from 200 m):

$$y_1 = 200 - \frac{1}{2}gt^2$$

For the second ball (thrown upward):

$$y_2 = v_0 t - \frac{1}{2} g t^2$$

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Equating $y_1 = y_2$:

$$200 - \frac{1}{2}gt^2 = v_0t - \frac{1}{2}gt^2$$

Simplifying:

$$200 = v_0 t$$

$$t = \frac{200}{v_0} = \frac{200}{50} = 4 \, seconds.$$

(b) The height at which the two balls meet:

Substitute t = 4 into y_2 :

$$y = v_0 t - \frac{1}{2}gt^2 = 50(4) - \frac{1}{2}(9.8)(4)^2$$

$$y = 200 - 78.4 = 121.6 meters.$$

(c) The velocities of both balls at the point of meeting:

For the first ball:

$$v_1 = -gt = -(9.8)(4) = -39.2 \, m/s.$$

For the second ball:

$$v_2 = v_0 - gt = 50 - (9.8)(4) = 50 - 39.2 = 10.8 \, m/s.$$

- 28. A car moving at 25 m/s decelerates uniformly to a stop over a distance of 100 m. It then reverses direction, accelerating uniformly at 2 m/s² until it reaches a velocity of 20 m/s. Calculate:
 - (a) (2 points) The time taken to stop.
 - (b) (4 points) The time taken to reach 20 m/s in reverse.
 - (c) (4 points) The total distance covered by the car.

Solution: (a) The time taken to stop:

Using $v^2 = u^2 + 2as$:

$$0 = 25^2 + 2(-a)(100)$$

$$625 = 200a \implies a = -3.125 \, m/s^2$$

$$t = \frac{v - u}{a} = \frac{0 - 25}{-3.125} = 8 \, seconds.$$

(b) The time taken to reach 20 m/s in reverse:

Using v = u + at:

$$t = \frac{v - u}{a} = \frac{20 - 0}{2} = 10$$
 seconds.

(c) The total distance covered by the car:

First phase (deceleration):

$$s_1 = \frac{1}{2}(u+v)t = \frac{1}{2}(25+0)(8) = 100 \, meters.$$

Second phase (reverse motion):

$$s_2 = \frac{1}{2}(u+v)t = \frac{1}{2}(0+20)(10) = 100 \, meters.$$

Total distance:

$$s = s_1 + s_2 = 100 + 100 = 200 \, meters.$$