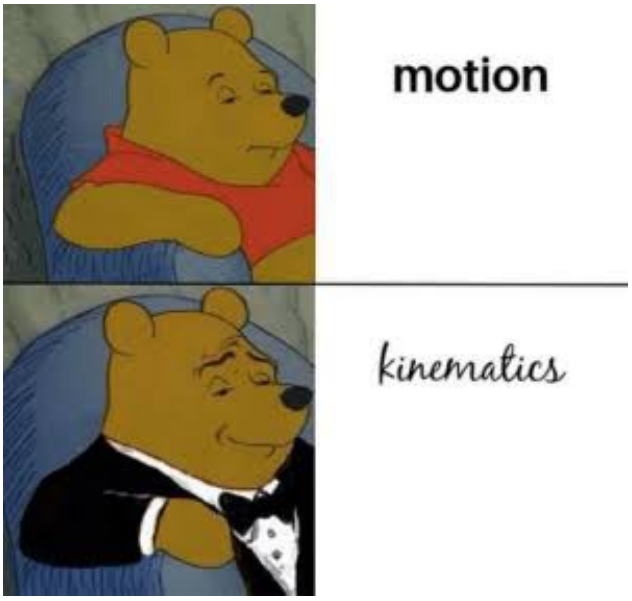


# Grade 12 Physics
# Kinematics Key

First Name: _____**KEY**_____

Last Name: _____

**Directions:**

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

*For grading use only*

| Page: | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 $g = 9.8$ $m/s^2$.)

   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 $g = 9.8$ $m/s^2$.)

   **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 $g = 9.8$ $m/s^2$.)

   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 $g = 9.8$ 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 $g = 9.8$ 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 $g = 9.8$ 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/s$^2$. 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 $g = 9.8$ 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 $g = 9.8$ 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/s$^2$ 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:**

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

**Rearranging, we get:**

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

- **Displacement ($s$) is given by:**

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

**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/s$^2$ 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,** $u = 0\,\text{m/s}$**.**

**(a) The acceleration is already given as:**

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

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

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

**Substitute the given values:**

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

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

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

**Final answers:**

- **(a) The acceleration is** $2\,\text{m/s}^2$**.**
- **(b) The distance traveled is** $225\,\text{m}$**.**

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,** $u = 50\,\text{m/s}$**,**
- **Acceleration due to gravity,** $a = -9.8\,\text{m/s}^2$**.**

**(a) To calculate the maximum height (**$h$**), we use the kinematic equation:**

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

**where** $v = 0\,\text{m/s}$ **at the maximum height.**
**Substitute the values:**

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

$$0 = 2500 - 19.6h,$$

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

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

$$v = u + at.$$

**Substitute the values:**

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

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

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

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

**Final answers:**

- **(a) The maximum height is approximately** $127.55\,\text{m}$**.**
- **(b) The total time to return to the ground is approximately** $10.20\,\text{s}$**.**

24. Two cars start from rest at the same point. Car A accelerates uniformly at 3 $\text{m/s}^2$, while Car B accelerates uniformly at 2 $\text{m/s}^2$. 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,** $a_A = 3\,\text{m/s}^2$**,**
- **Acceleration of Car B,** $a_B = 2\,\text{m/s}^2$**,**
- **Both cars start from rest** ($u_A = u_B = 0\,\text{m/s}$)**.**

**(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:**

$$s_A - s_B = 30,$$

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

$$0.5t^2 = 30,$$

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

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

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

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

**Final answers:**

- **(a) The time it takes for Car A to be 30 m ahead of Car B is approximately** $7.75\,\text{s}$**.**
- **(b) The distance covered by Car A is** $90\,\text{m}$**, and by Car B is** $60\,\text{m}$**.**

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,** $u = 25\,\text{m/s}$**,**
- **Acceleration due to gravity,** $a = -9.8\,\text{m/s}^2$**,**
- **Second ball is thrown** $t = 2\,\text{s}$ **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:**

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

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

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

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

**Final answers:**

- **(a) The two balls meet at approximately $t = 3.55\,\text{s}$ after the first ball is thrown.**
- **(b) The height at which they meet is approximately $27.12\,\text{m}$.**

26. A cyclist starts from rest and accelerates uniformly at a rate of 1.5 $\text{m/s}^2$ 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 $a_1 = 1.5\,\text{m/s}^2$,**
- **Time of acceleration $t_1 = 12\,\text{s}$,**
- **Constant velocity time $t_2 = 20\,\text{s}$,**
- **Deceleration time $t_3 = 8\,\text{s}$.**

**Solution:**

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

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

**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 $18\,\text{m/s}$ over $12\,\text{s}$,**
- **A horizontal segment at $18\,\text{m/s}$ for $20\,\text{s}$,**
- **A linearly decreasing segment from $18\,\text{m/s}$ to $0$ over $8\,\text{s}$.**

**(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:**

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

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

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

**Total distance:**

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

**(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** $540\,\text{m}$**.**
- **(c) The average velocity for the entire trip is** $13.5\,\text{m/s}$**.**

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):**

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

**For the second ball (thrown upward):**

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

**Equating $y_1 = y_2$:**

$$200 - \frac{1}{2}gt^2 = v_0 t - \frac{1}{2}gt^2$$

**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/s$^2$ 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 $v^2 = u^2 + 2as$:**

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

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

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

**(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:**

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