Delta Science Education

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HKDSE Physics

Core 2: Force and Motion

Chapter 1: Position and Movement

Part 2

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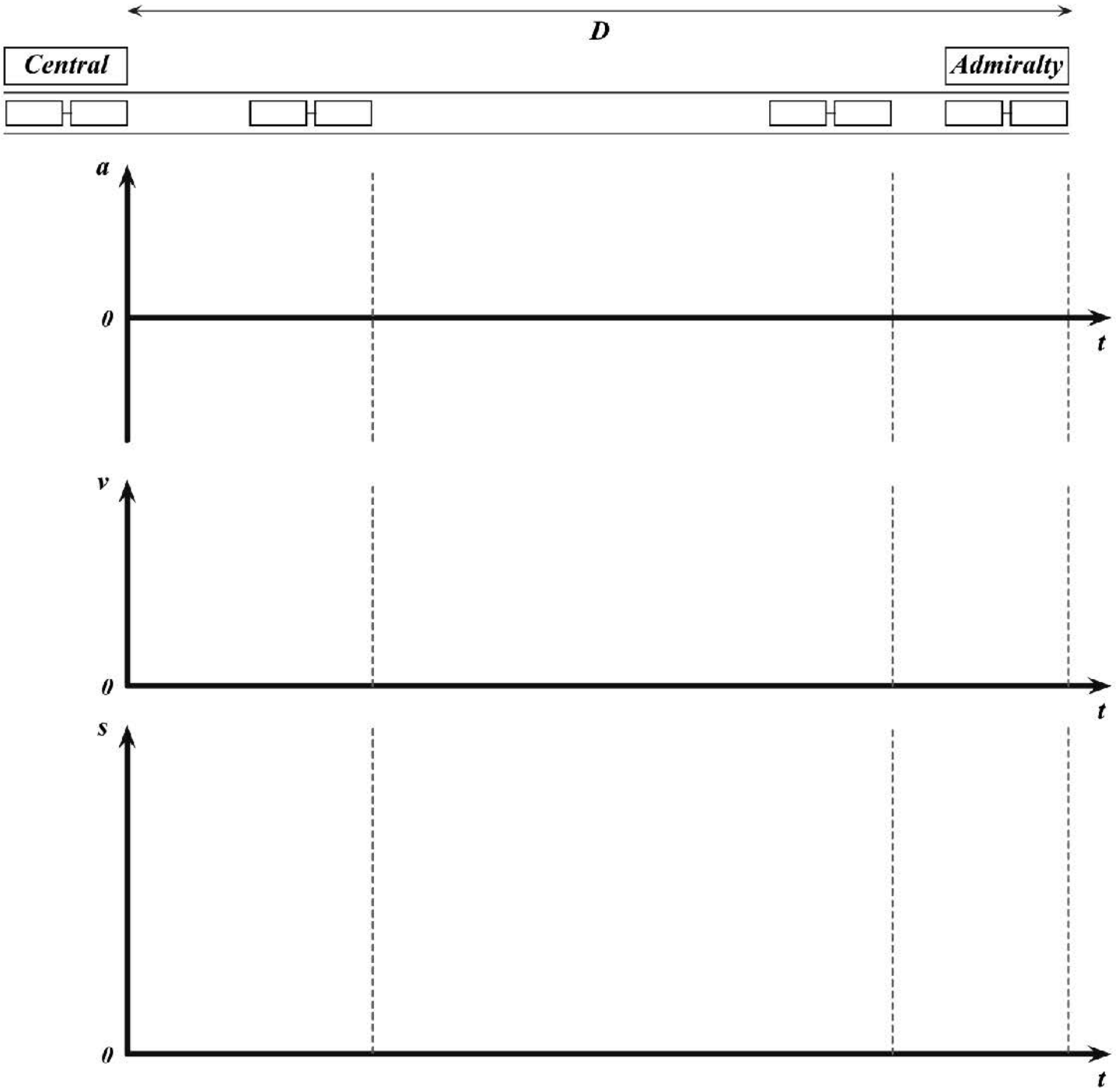
5. Typical Motion of Vehicles

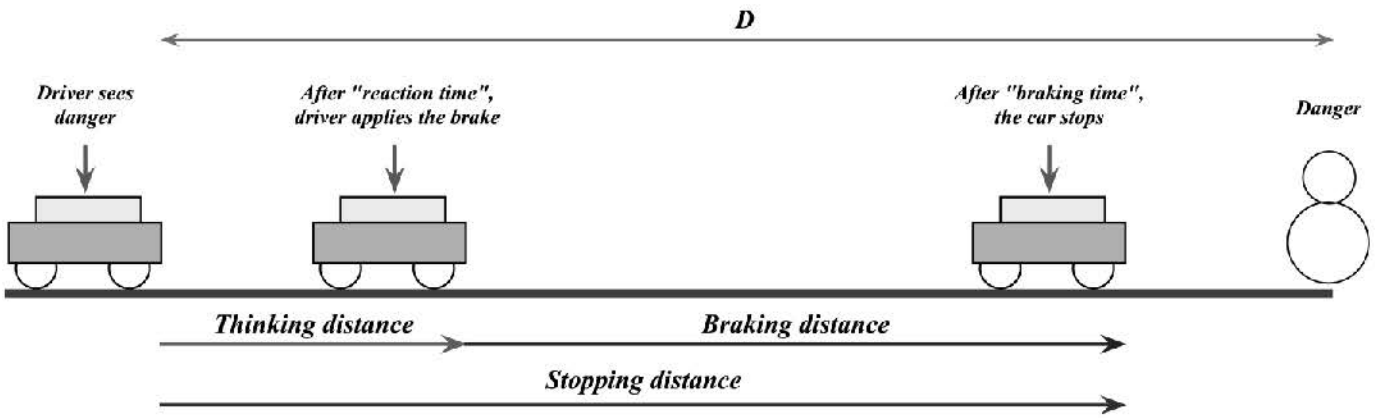
(1) Simple Motion of a Train between Two Stations

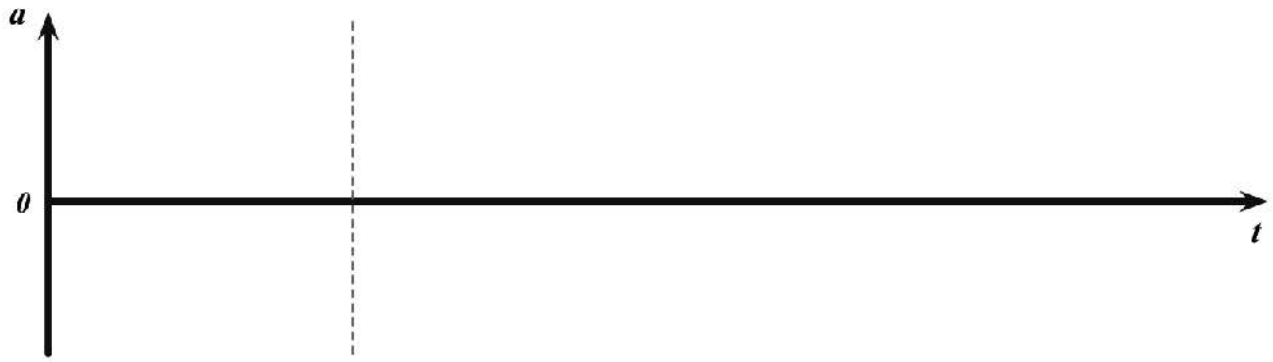
- For a train moving from one station to another station, it must undergo:



(2) Braking of a Car

- For a driver who sees a danger, he must undergo **a** [ ] **time** before applying the brake to stop the car.

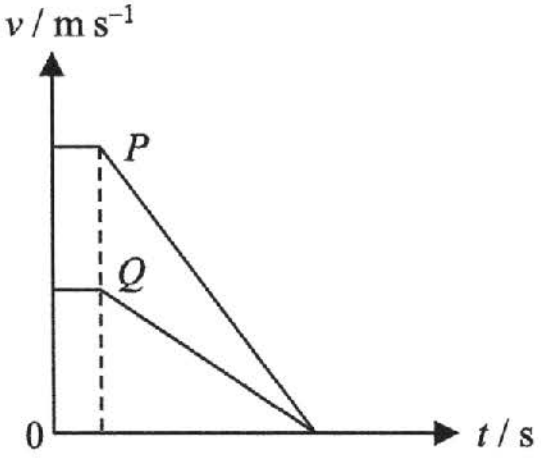




Examples that you must fully understand

1. A train departs from one station and stops at the next station after travelling 1.2 km along a straight line. The maximum acceleration and deceleration of the train are both 5 m s^{-2} and the highest speed of the train is limited to 20 m s^{-1}. Find the shortest time taken for this trip. (Tips: try to draw the *v*-*t* graph)

2. John and Mary are driving two cars, *P* and *Q*, along a straight horizontal road respectively. At time $t = 0$, they both see an obstacle and apply the brakes to stop the cars with uniform deceleration. The variation of velocity with time of the two cars is shown in the figure below. Which of the following statements is/are correct?



(1) The two cars have the same initial speeds.

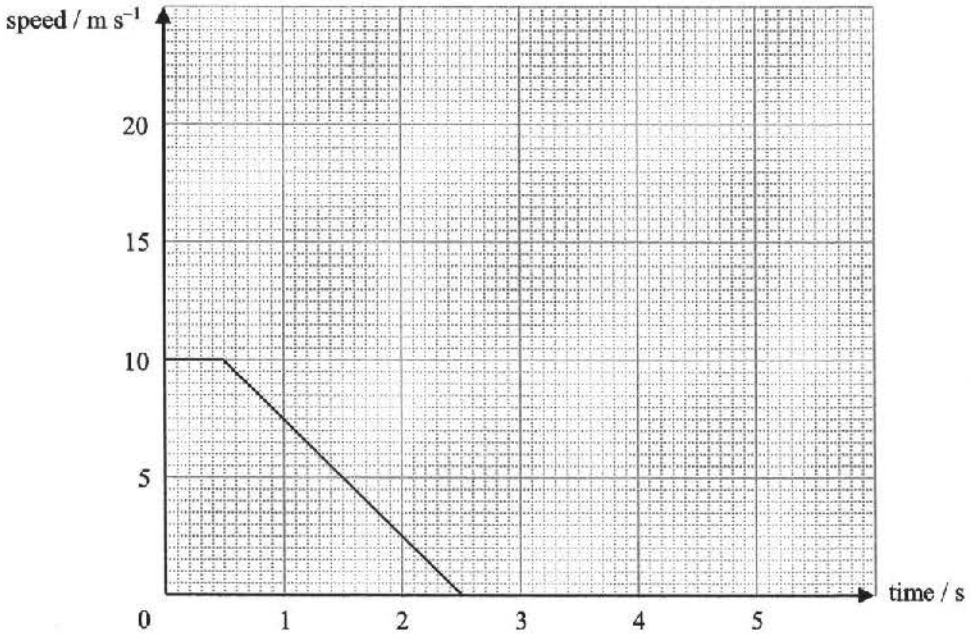
(2) The reaction times of John and Mary are the same.

(3) The total stopping distances of the two cars are the same.

(4) The two cars have the same deceleration.

Examples that you must fully understand

3. A car is travelling at a uniform speed of 10 m s^{-1}. The driver sees a warning signal and applies the brakes to bring the car to rest with uniform deceleration. The figure below shows the speed-time graph of the car, starting from the instant the driver first sees the signal.



(a) If there is an obstacle 20 m ahead when the driver first sees the signal, would the car hit the obstacle? Explain your answer.

(b) Assume that the reaction time of the driver and the deceleration of the car remain unchanged.

(i) In the figure above, draw (in a dotted line) a speed-time graph for the car if it is initially travelling at 20 m s^{-1}.

(ii) A student says "If the initial speed of the car is doubled, the stopping distance of the car would also be doubled." State whether his statement is true or false and explain briefly.

Examples that you must fully understand

4. A car is travelling with a speed u on a road. The stopping distance of it includes the thinking distance, l and the braking distance, s. Figure 1 shows the variation between l and s with u.

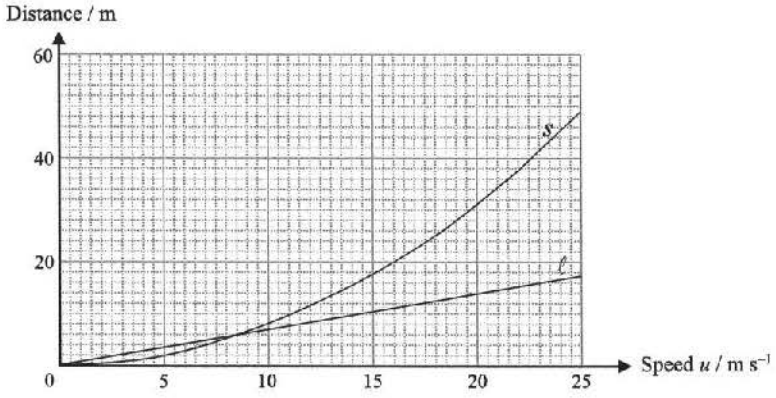


Figure 1

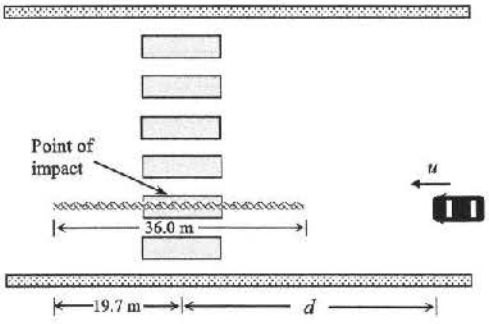


Figure 2

(a) Find the slope of the straight line in Figure 1 and state its physical meaning.

(b) Assume the deceleration, a of the car remains unchanged at different speeds. Write down an equation relating u, s and a. Thus, by using the Figure 1, find the value of a.

(c) A boy was hit by the car when he was crossing a zebra-crossing. Figure 2 below shows a sketch of the accident drawn by the police. Let d be the distance between the car and the boy at the moment the driver first observed the boy. The driver applied the brakes and a skid mark 36.0 m long was left on the road. After hitting the boy, the car travelled a distance of 19.7 m before coming to rest. You may neglect the change in speed of the car during the impact.

(i) Write down the braking distance of the car.

(ii) Using Figure 1, estimate the value of u.

(iii) Estimate the thinking distance and the value of d.

6. Gravity

(1) The Leaning Tower Experiment

- Aristotle said "A heavier ball falls faster than a lighter ball."
- Galileo performed an experiment in Italy in the sixteenth century. He dropped two balls of different masses from the top of the Leaning Tower of Pisa.
- Result of the experiment: both of the balls reached the ground almost at the same time.
- Conclusion: "A heavier ball falls at the same rate as a lighter ball if air resistance is negligible."

(2) Acceleration due to Gravity

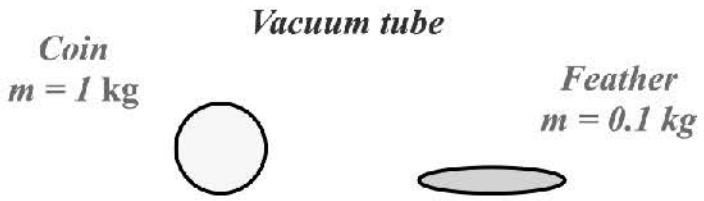
- A free-falling object is an object that is falling under the **sole influence** of [ ], thus, **air resistance is** [ ].
- Free-falling is irrelevant to the initial motion of the objects:

- All free-falling objects fall down with the same acceleration, called "**acceleration due to gravity**", g.
- The value of the acceleration due to gravity depends on [ ] but independent of the [ ] of the free-falling objects. For the g on the surface of the Earth:

direction: always pointing

Examples that you must fully understand

5. A coin and a feather are released from rest at the same position in vacuum. It is found that they reached the bottom at the same time. Which of the following is / are correct deduction from this experiment?



(1) The mases of the coin and the feather are identical in vacuum.

(2) The coin falls down with a greater acceleration.

(3) The gravitational force acting on the coin and the feather respectively are identical.

(4) Both of them reach the ground at the same time.

6. A ping-pong ball and an iron ball are released from the same height at the same time in air. Which of the following statements is / are correct?

(1) The iron ball falls down with a greater acceleration.

(2) The iron ball reaches the ground first.

(3) The iron ball reaches the ground with a greater speed.

(4) The ping-pong ball falls down with uniform velocity.

7. An object is falling from rest with an acceleration of 9.81 m s^{-2}. Which of the following statements is/are correct?

(1) It falls with a constant speed of 9.81 m s^{-1}.

(2) It falls 9.81 m every second.

(3) It has a speed of 19.62 m s^{-1} after 2 s.

Examples that you must fully understand

8. A ball is released from rest. Neglect air resistance in this question.

(a) Find the distance travelled by the ball in 5 seconds.

(b) Find the velocity of the ball at the instant of 5 s.

(c) Find the average velocity during the first 5 seconds.

(d) Find the distance travelled by the ball in the 5^{th} second.

9. A boy wants to measure the height of a building. He goes to the top of the building and throws the iron ball downwards at an initial velocity of 5 m s^{-1}. A girl on the ground uses a timer to measure the time taken for the ball to reach the ground.

(a) If it takes 7.8 s to reach the ground, find the height of the building.

(b) Calculate the velocity of the ball when it hits the ground.

(c) Why an iron ball is better than a wooden ball in this experiment.

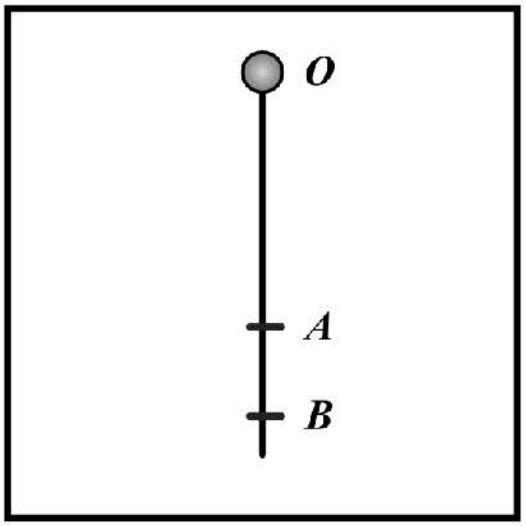
Since an iron ball is [ ] than a wooden ball, the effect of [ ] on an iron ball is less.

10. A feather is dropped downwards with an initial velocity of 2 m s^{-1} at a height of 15 m above the surface of the Moon. It is known that the acceleration due to gravity on the Moon's surface is 16% of that of the Earth. Calculate the speed of the feather when it reaches the surface of the Moon.

Examples that you must fully understand

11. A body is dropped from rest down a cliff on a planet X. After falling for 1 s, it is 4 m below the starting point. How far below the starting point will it be after a further 4 s?

12. A particle released from rest at O falls freely under gravity and passes A and B, as shown in the figure (not drawn to scale). If the particle takes 4 s to move from A to B, where AB = 100 m, how long does it take to fall from O to A? You can take g as 10 m s^{-2}.



Examples that you must fully understand

13. Susan uses the following method to examine John's reaction time:

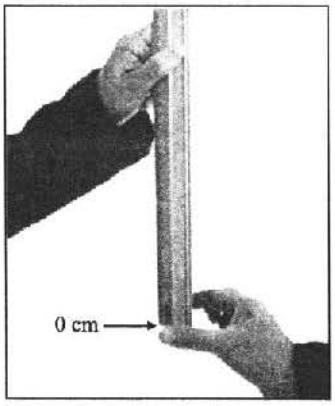


Figure 1

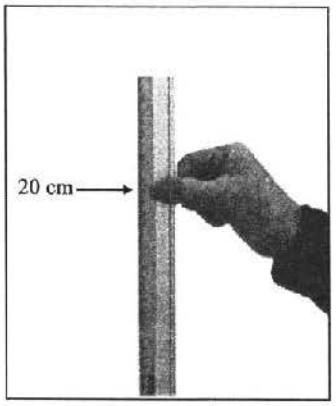


Figure 2

She holds a graduated ruler upright with the zero mark starting at the bottom. John lines up his fingers near the bottom of the ruler. (See Figure 1.) Without any warning, Susan releases the ruler and John grips the ruler with his finger as fast as possible. It is found that John grips at the 20 cm mark of the ruler. (See Figure 2.) Take the acceleration due to gravity g to be 10 m s^{-2}.

(a) Show that John's reaction time is 0.2 s.

(b) If a heavier ruler is used, how would the result of the above test be affected? Explain your answer.

The result [ ] because the acceleration due to gravity is [ ] of the mass.

(c) Susan marks the other side of the ruler as shown in Figure 3 so that the reaction time can be read directly. Explain whether Susan's scale for the reaction time is correct or not.

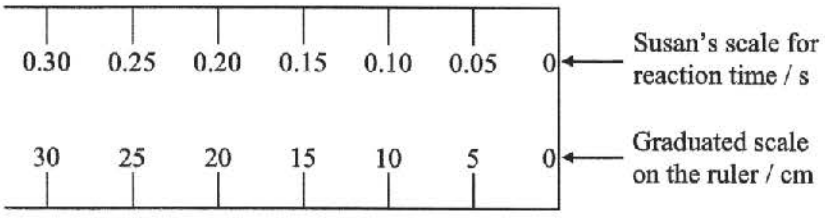
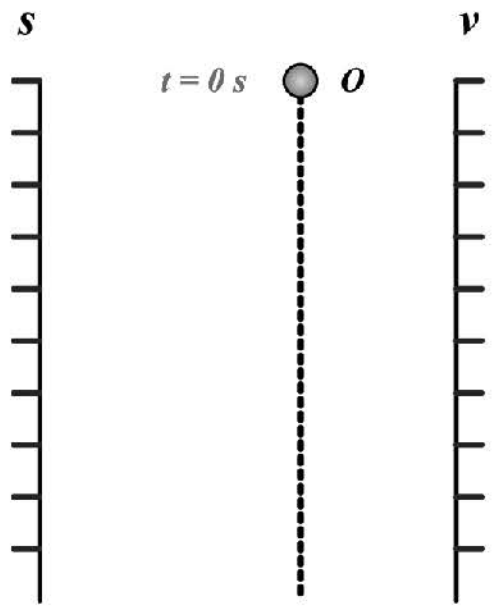


Figure 3

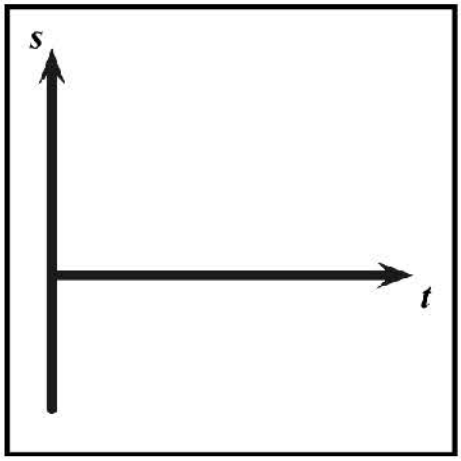
(3) Falling Analysis

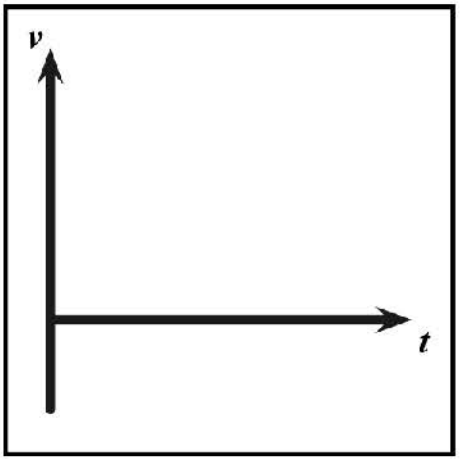
- Consider a particle released from rest falls freely in vacuum:

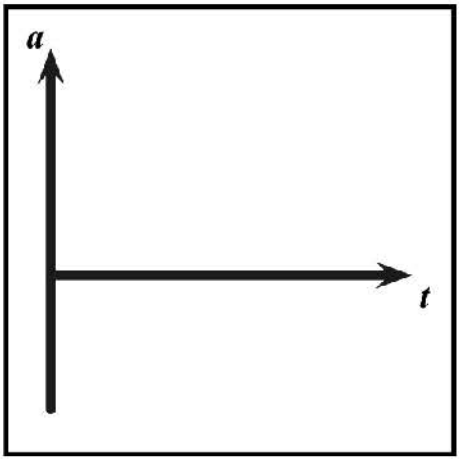
Quantities	How does it change?
Acceleration	**Constant,**
Velocity	
Displacement	

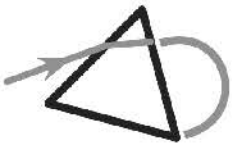


- Motion graphs of a free-falling object: (Taking downwards as positive)









Examples that you must fully understand

14. An iron ball is released from rest and dropped to the ground. Air resistance is neglected and the acceleration due to gravity is taken to be 10 m s^{-2}. Which of the following statements is / are correct?

$t = 0$ ○

$t = 1$ s ○

$t = 2$ s ○

(1) When the iron ball is just released, the velocity of the ball is zero.

(2) When the iron ball is just released, the acceleration of the ball is zero.

(3) The acceleration of the ball increases 10 m s^{-2} in every second.

(4) The velocity of the ball increases 10 m s^{-1} in every second.

(5) The displacement of the ball increases 10 m in every second.

15. A particle is released from rest and falls vertically under gravity. If the distance travelled by the particle in the 1st second is x and that travelled in the 2nd second is y, find the ratio of $x : y$. Hence, if the velocity of the particle at the moment of 1st second is u and that at the moment of 2nd second is v, find also the ratio of $u : v$.

16. A stone is released at the top of a building from rest. If the stone takes 2 s to reach the mid-height of the building, and air resistance is neglected, which of the following statements is / are correct?

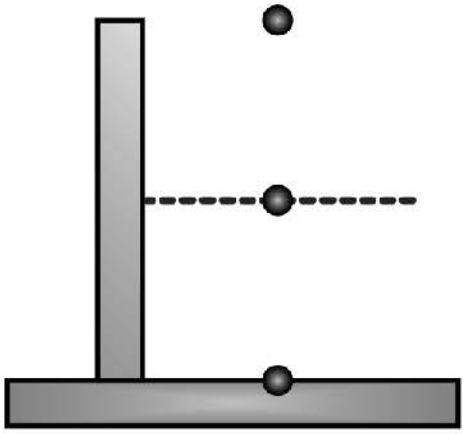
(1) The stone takes 4 s to reach the bottom of the building from the top.

(2) The stone reaches the bottom of the building with a speed of 40 m s^{-1}.

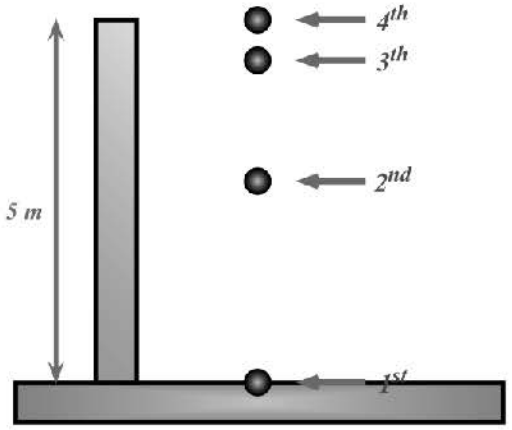
(3) The height of the building is 40 m.

Examples that you must fully understand

17. An object is released from rest at the top of a building. If it takes 1.2 s to fall from the mid-point of the building to the ground, what is the time taken for it to fall from the top to the ground?

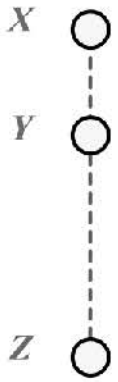


18. In a certain day, raindrops fall down consecutively one after the other at a certain time interval T from the roof of a building at a height of 5 m. Just when the first raindrop reaches the ground, the fourth raindrop is going to leave the roof. What is the height of the second raindrop from the ground?



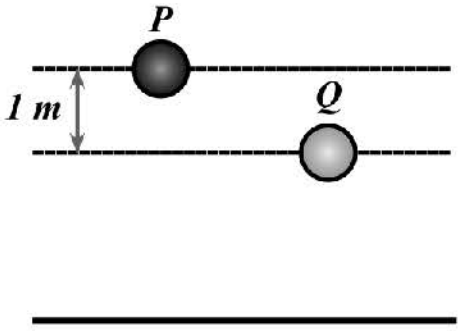
Examples that you must fully understand

19. A particle is released from rest at X as shown. It takes time t_1 to fall from X to Y and time t_2 to fall from Y to Z. If $XY : YZ = 9 : 16$, find $t_1 : t_2$. Neglect air resistance.



20. Two small identical objects P and Q are released from the top of a building 80 m above the ground. Q is released 1 s after P. Neglecting air resistance, what is the maximum vertical separation between P and Q in the air?

21. Two balls, P and Q are placed so that P is 1 m higher than Q. They are dropped from rest at the same time. Assume air resistance is negligible. Which of the following statements is correct?



(1) Before Q reaches the ground, the balls are travelling with the same speed.

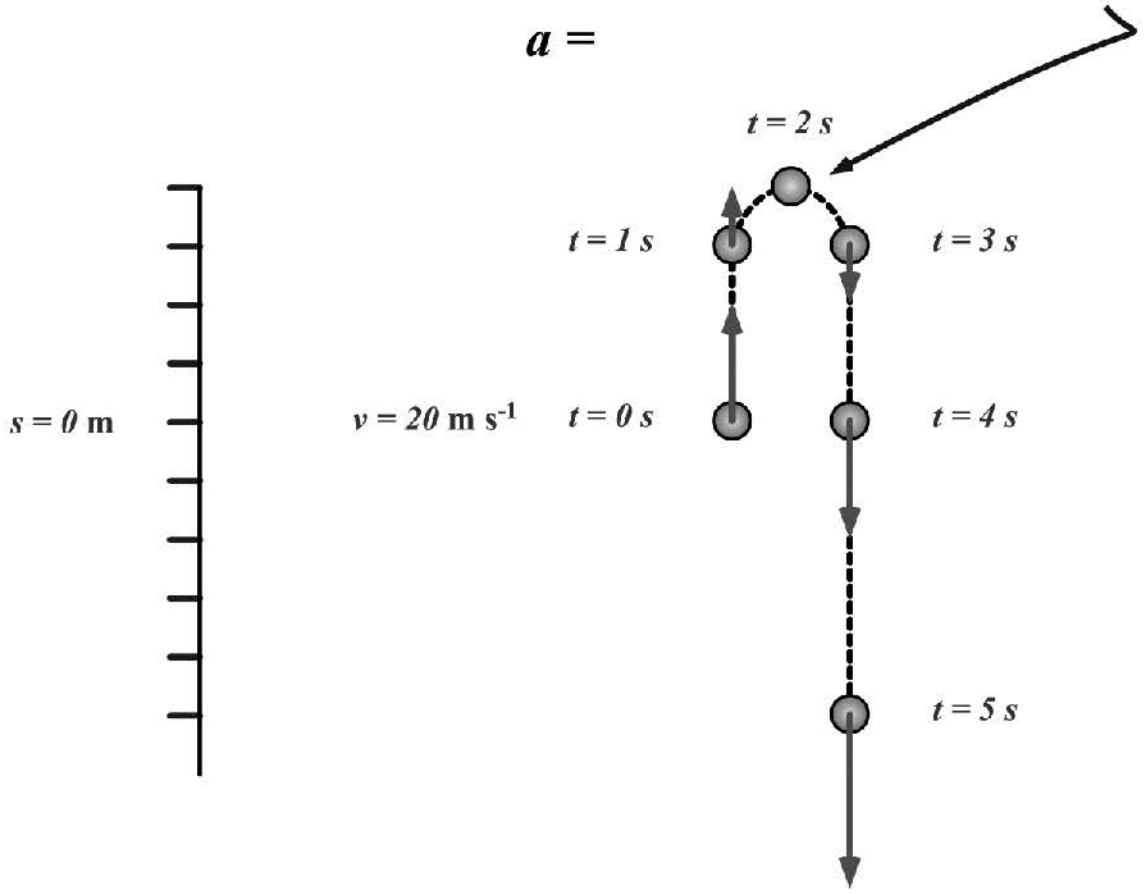
(2) Before Q reaches the ground, the separation between the balls is always 1 m.

(3) P will hit the ground with a higher speed.

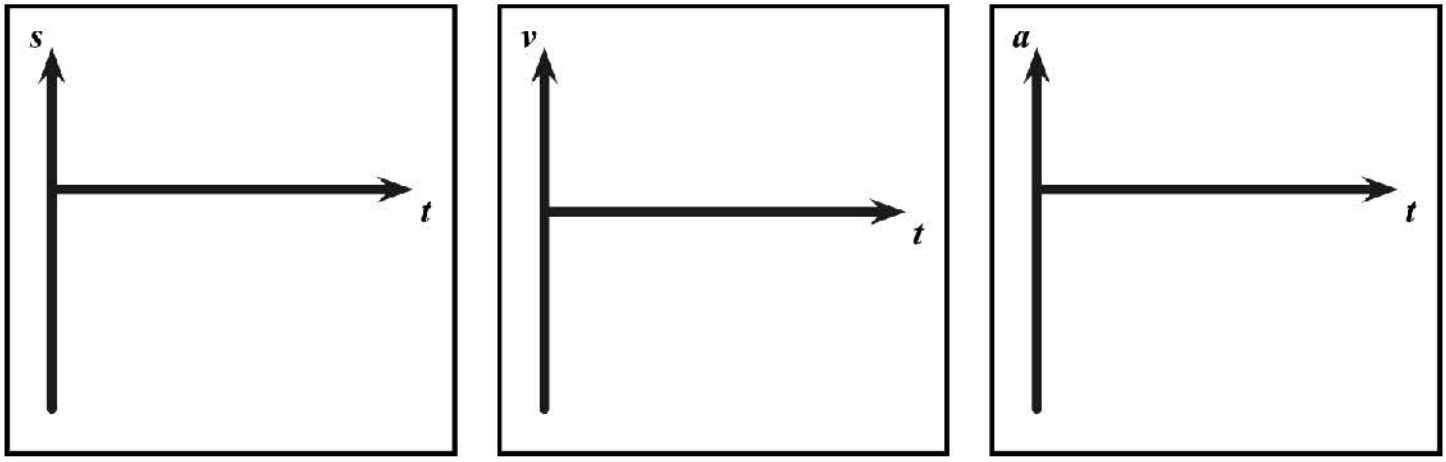
(4) P will hit the ground 0.45 s after Q.

(4) Projecting up Analysis

- Consider a particle is projected up in vacuum at an initial speed of 20 m s^{-1}. The starting time (t = 0) is considered at the instant that the ball leaves the hand.



- Motion graphs of an object being thrown upward: (Taking downwards as negative)



Examples that you must fully understand

22. A fish jumps up vertically and can just touch a leave 1.5 m above the bottom of the lake. What is the speed when it just leaves the surface if the deapth of the lake is 1 m?

23. A ball is being projected upward. It takes 2 s to reach its highest point and then falls down to the original position. Which of the following statements concerning the motion of the ball is / are correct?

(1) It also takes 2 s to fall to the original position from the highest point.

(2) The ball reaches the original position with the same velocity as it is projected.

(3) The ball reaches the original position with the same speed as it is projected.

(4) When the ball reaches the highest point, it is moving downwards.

(5) At the highest point, the ball's acceleration is zero.

(6) Before the ball reaches the highest point, its acceleration is pointing up but after the ball reaches the highest point, its acceleration is pointing down.

(7) When the ball returns the original position, its total displacement is zero.

24. A landing module is ascending from the Moon's surface at a steady velocity of 20 m s^{-1}. At a height of 100 m above the Moon's surface, a screw nut of mass 50 g detached from the module. If the gravitational acceleration on the Moon's surface is only one sixth of the gravitational acceleration on the Earth, what is the time taken for the screw nut to reach the ground?

Examples that you must fully understand

25. A helicopter is ascending with a uniform velocity of 50 m s^{-1}. When it is at a height of 120 m above the ground, a stone is released from the helicopter.

(a) Find the maximum height from the release position that the stone can reach.

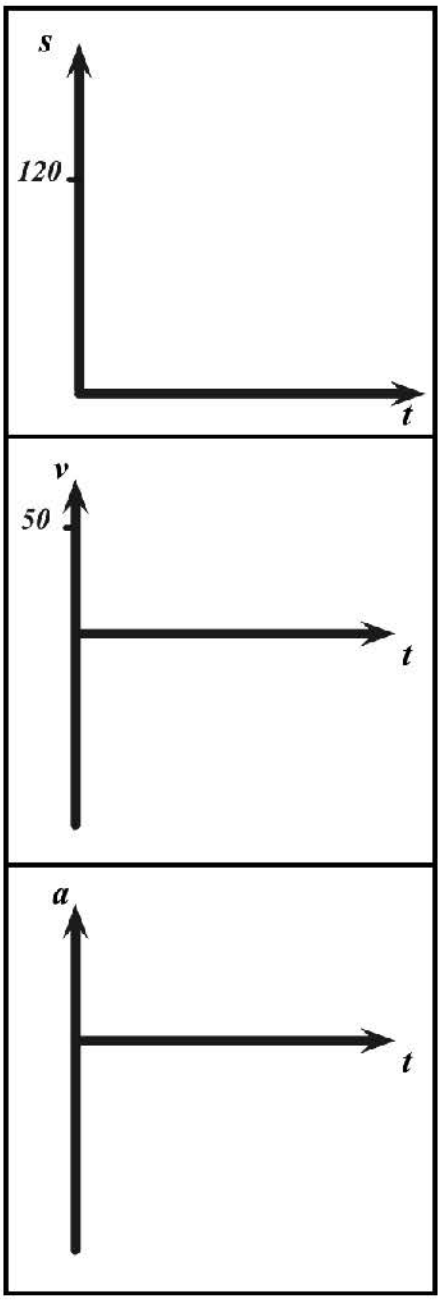
(b) Find the time taken to reach the maximum height.

(c) Find the time taken to reach the release position.

(d) Find the velocity when it reaches the ground.

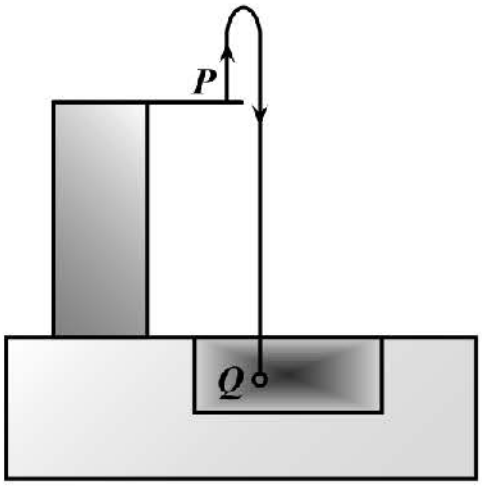
(e) Find the time taken to reach the ground.

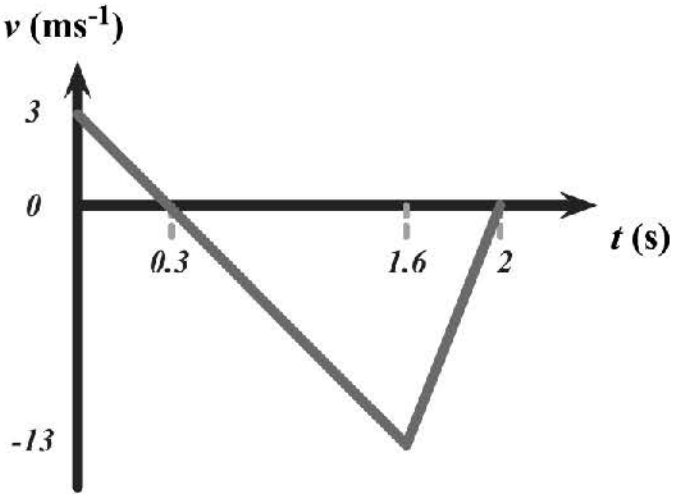
(f) Sketch the s-t, v-t and a-t graphs of the stone from the moment it is released from the helicopter to the moment it reaches the ground.



Examples that you must fully understand

26. A diver jumps up vertically in the air from a high platform and falls into water. The *v*-*t* graph shows the variation of the velocity of the diver against time from the point he jumps (*P*) until he is at the lowest point (*Q*) in the water.





(a) What is the height of the platform above water surface?

(b) What is the maximum height of the diver relative to the water surface?

(c) How deep can the diver go below the water surface?

(d) Calculate the deceleration of the diver in water?

(e) Calculate the average velocity of the diver for the whole journey.

(f) Comment on the following two statements:

Statement 1: At time t = 0.3 s, the acceleration of the diver is zero.

The statement is

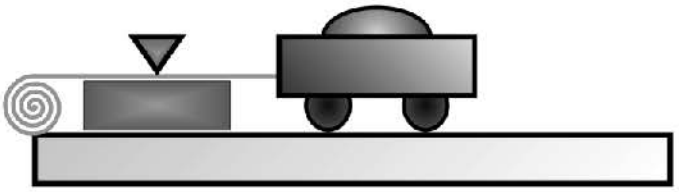
Statement 2: If the diver is replaced by the other one heavier, it would not be able to reach the same maximum height as the original diver.

The statement is

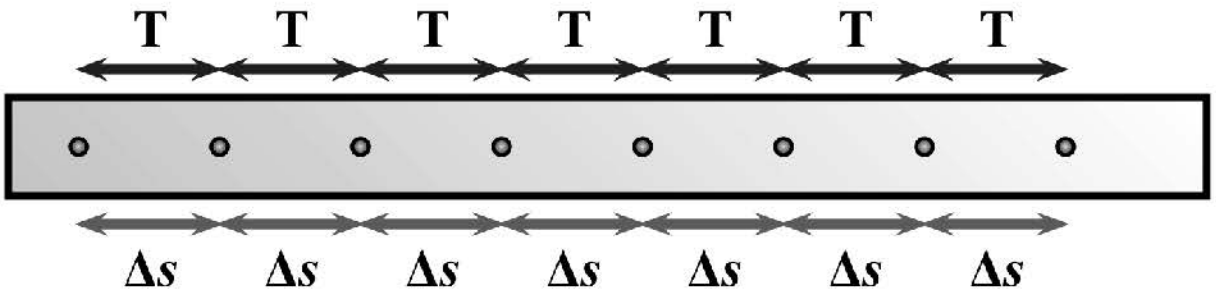
7. Time Measuring Devices

(1) Ticker-tape Timer

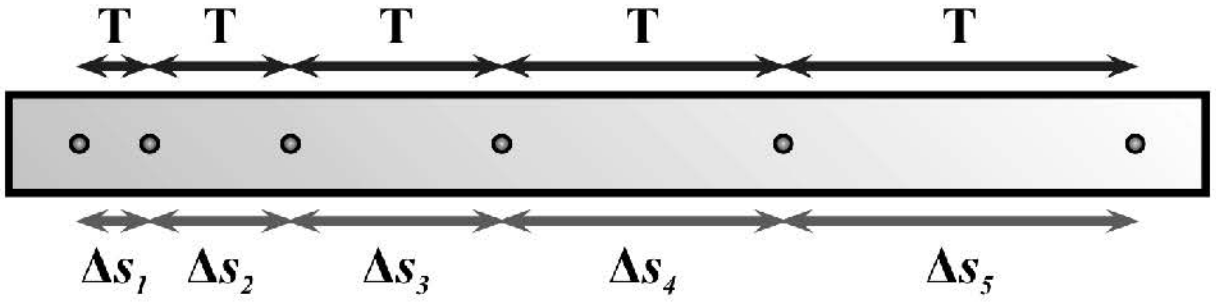
- A ticker-tape timer operates at a certain frequency, f and strikes a dot on a paper tape after a certain period of time called tick, T.



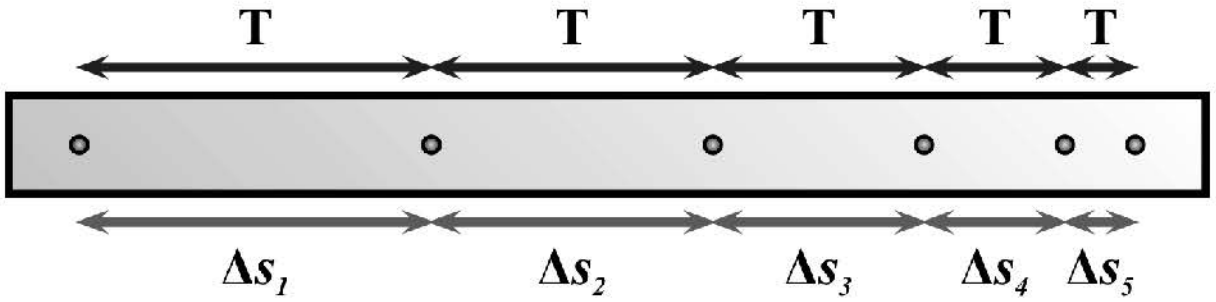
Uniform velocity



Accelerating

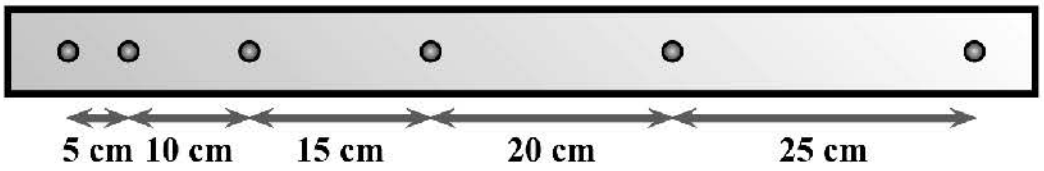


Decelerating



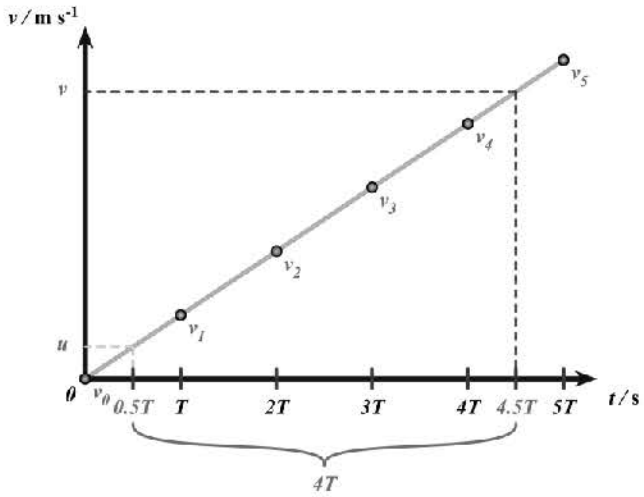
Examples that you must fully understand

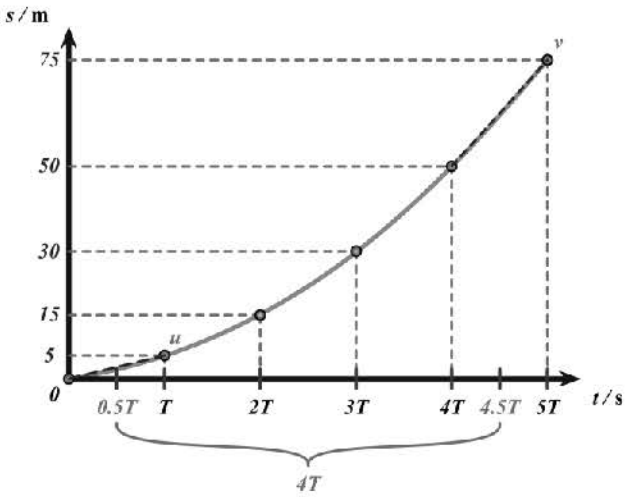
27. The diagram on the right shows a paper tape obtained in an experiment of a moving car. The frequency of the ticker-tape timer is 50 Hz.



(a) Calculate the time interval between two dots (= one tick).

(b) Calculate the average velocity between the first two dots and that between the last two dots.





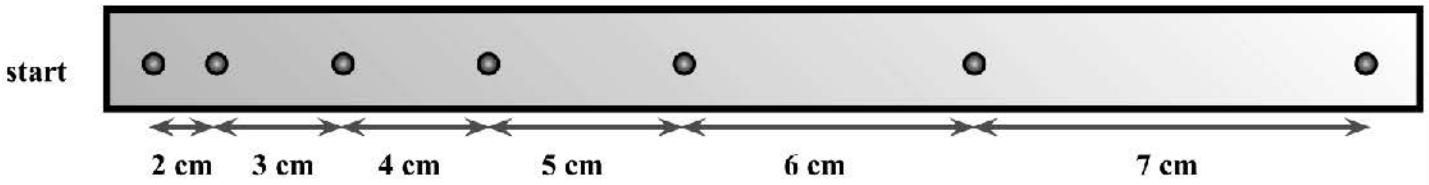
(c) Compare the average velocity between the first two ticks with the instantaneous velocities at t = 0 s and t = 0.02 s.

It is

(d) Find the acceleration of the car.

Examples that you must fully understand

28. The figure below shows a section of the paper tape which is connected to a ticker timer with operation frequency 50 Hz. Which of the following statements is / are correct?



(1) The speed in the section BC is 2.25 m s^{-1}.

(2) The displacement increases uniformly from A to D.

(3) The velocity increases uniformly from A to D.

(4) The acceleration increases uniformly from A to D.

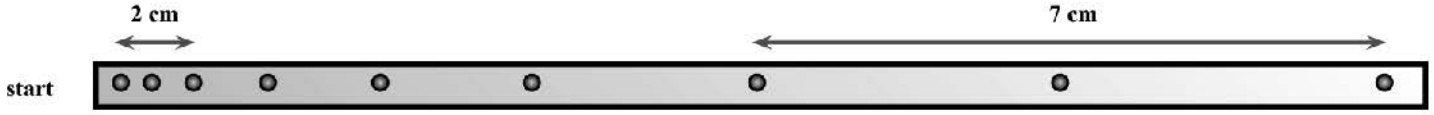
29. A body moves along a straight line. During the 1st second, it moves 1 m; during the 2nd second, it moves 2 m; during the 3rd second, it moves 3 m, etc. Which of the following statements must be correct?

(1) The displacement of the body from the starting point increases uniformly.

(2) The body moves with uniform velocity.

(3) The body moves with acceleration.

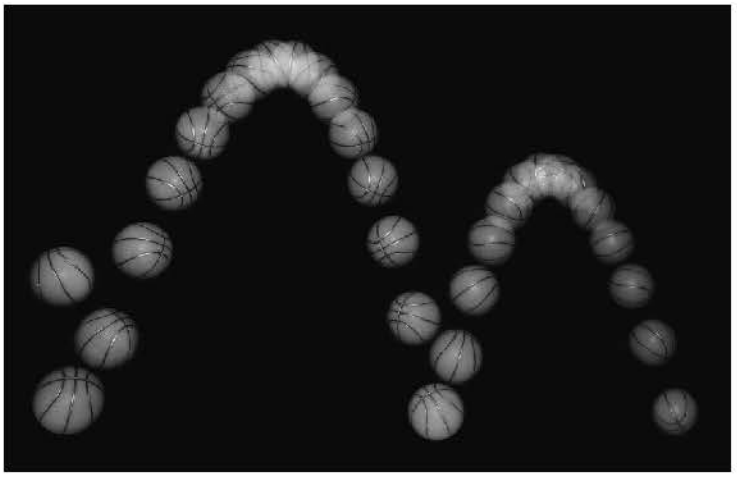
30. A ticker tape timer operated at 100 Hz produced the tapes below. Calculation the acceleration of the object.



(2) Stroboscope

- A stroboscope flashes at a certain frequency, f and the period between two flashes is T.

- A moving object can be photographed in a dark room by the illumination of a stroboscope. A camera records the image of the object each time the light flashes. This is also called multi-flash photograph.



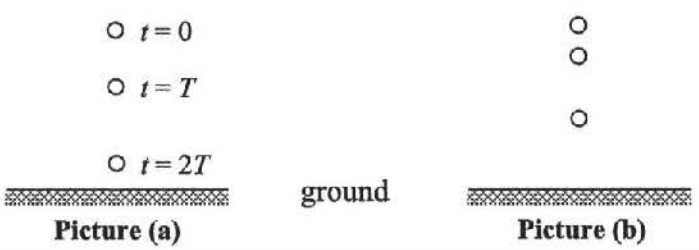
Examples that you must fully understand

31. An experiment is conducted by releasing a stone from rest to the ground. At constant time interval T, the positions of the stone are recorded. Picture (a) shows its positions at different time. Which of the following changes will give a path of the stone as shown in Picture (b)? (Neglect air resistance.)

(1) A shorter time interval is used.

(2) A lower recording frequency is used.

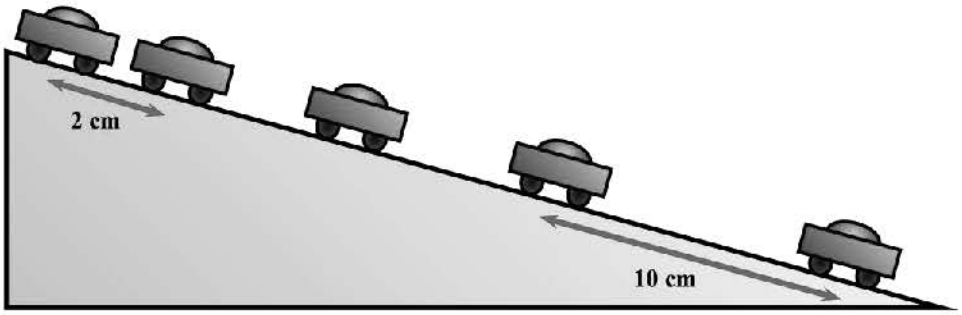
(3) A lighter stone is used.



Picture (a) Picture (b)

Examples that you must fully understand

32. The figure shows a flashed photo taken when a ball slides down a slope. The frequency of the flash is 20 Hz. Find the acceleration of the ball.



33. Figure 1 shows a stroboscopic picture when a ball bearing is released from rest inside a tube of oil.

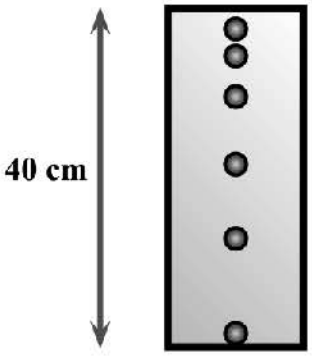


Figure (1)

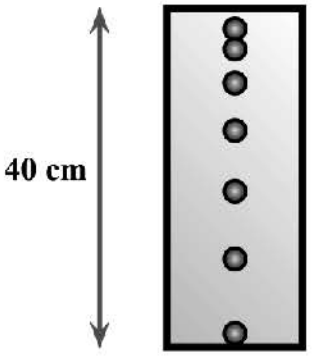


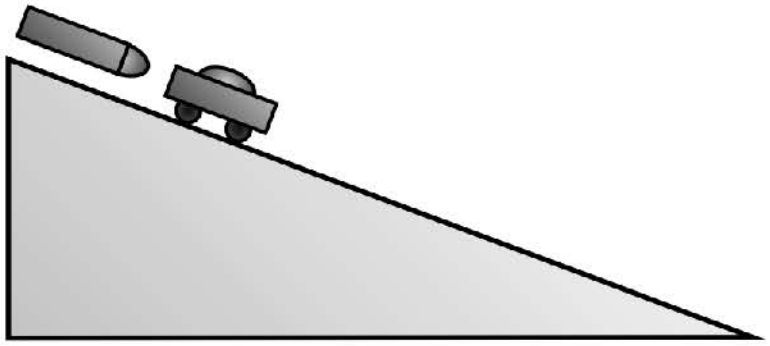
Figure (2)

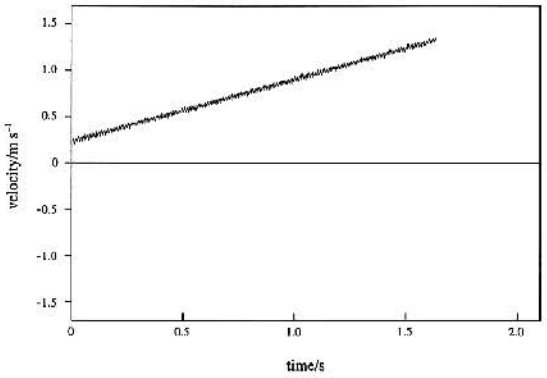
(a) If the frequency of the stroboscope is 10 Hz, find the acceleration of the ball.

(b) If the frequency of the stroboscope is slightly changed and then figure 2 is obtained. Determine the new frequency.

(3) Motion Sensor

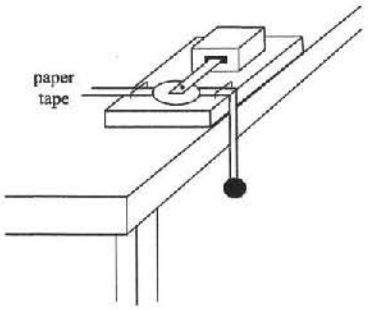
- A motion sensor emits ultrasound/microwaves and receives the echoes from the moving object.
- The data is recorded by a data logger and computer, displacement-time graph, velocity-time graph or acceleration-time graph can then be plotted.

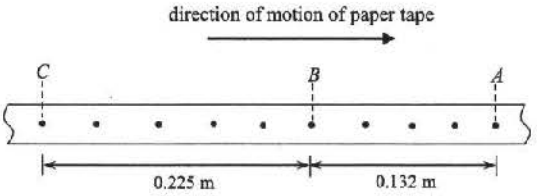




Examples that you must fully understand

34. The figure below shows an experimental set-up to find the acceleration due to gravity ***g***. The ticker-tape timer produces 50 dots per second. A light ping-pong ball attached to a paper tape is released from rest.





(a) The paper tape obtained from the experiment is shown above. By considering the motion AB and AC, calculate the acceleration due to gravity g obtained in this experiment.

(b) How would the result of g obtained from the experiment be affected if the ping-pong ball was replaced by a metal ball? Explain briefly.

The result of g would be [ ] since the air resistance will be [ ].

(c) State TWO precautions that should be taken in this experiment.

The ball should be [ ] enough so that air resistance is negligible.

Place polystyrene tile on the ground under the ball so that the ball would not hit the floor directly.

(4) Timer Scaler

- A timer scaler can be started or stopped by blocking a beam of light in a light gate.
- Compare with stop-watch, it is very sensitive and accurate and has almost no reaction time error.

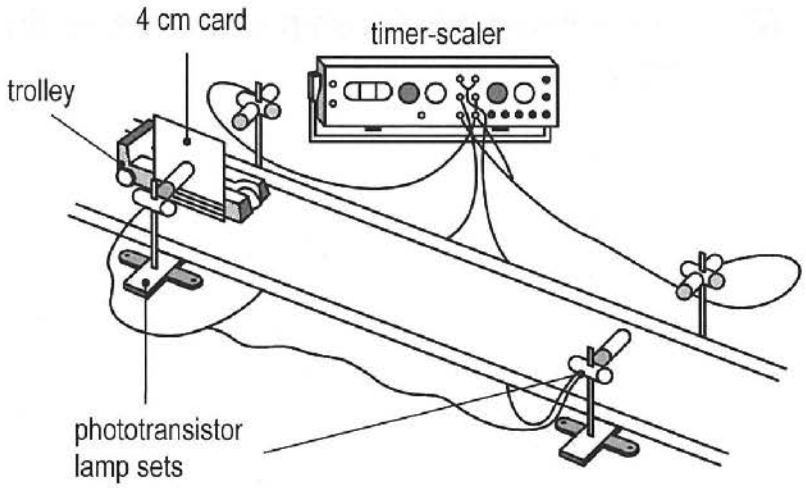
Examples that you must fully understand

35. John uses a digital stop-watch to measure the period of a simple pendulum and records a reading of 2.34 s.

(a) If the reaction time of him is 0.2 s, what is the percentage error of the measurement?

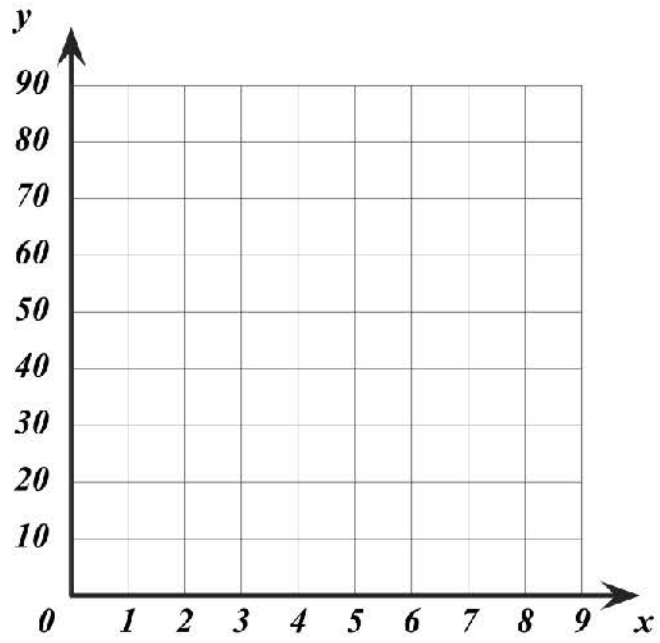
(b) If he now measured the time for 20 oscillations, what will be the percentage error of the measurement?

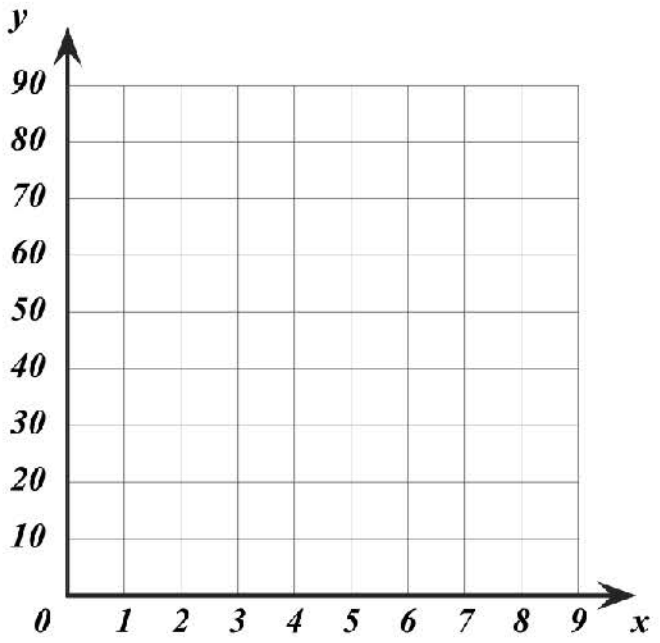
36. The timer-scaler will record the time elapsed during which the light from the lamp is cut off by the card on the trolley. It records 40 ms and 20 ms as the 4.0 cm card on the trolley passes the upper and lower phototransistor stations respectively. The time taken by the trolley to travel from the upper and lower station is 2.0 s. What is the acceleration of the trolley when it moves between these two phototransistors?



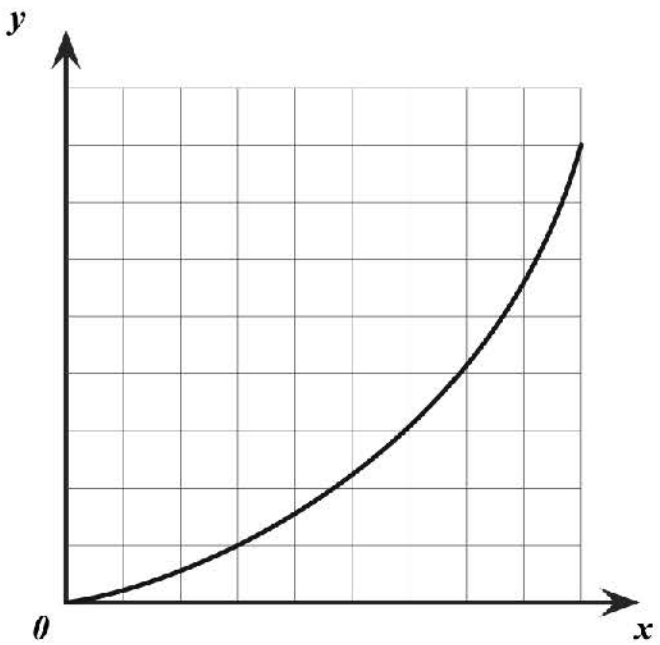
8. Graphical Methods

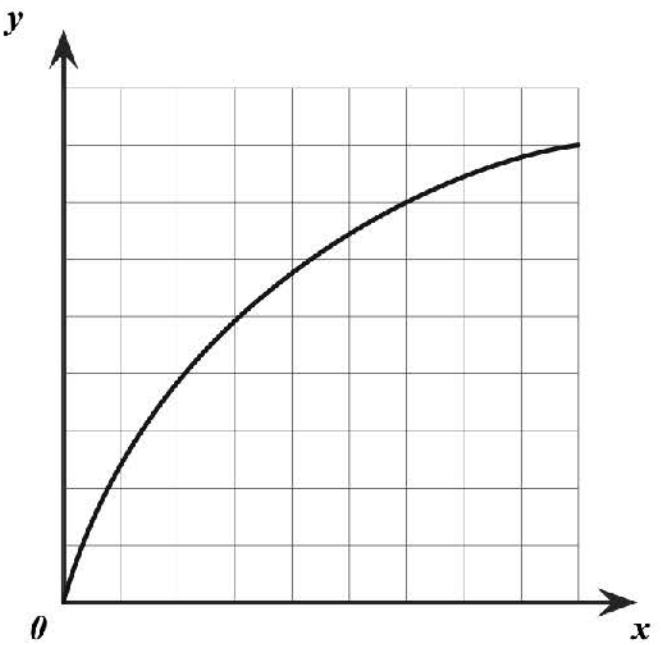
(1) Straight Line Graphs





(2) Quadratic Graphs

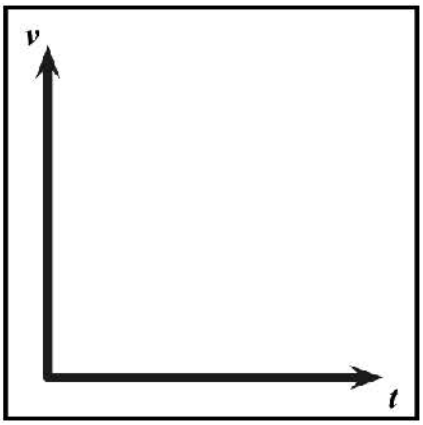




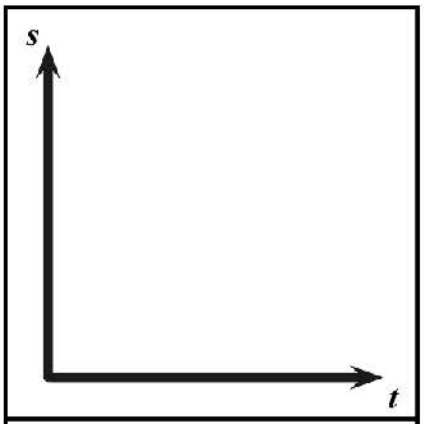
Examples that you must fully understand

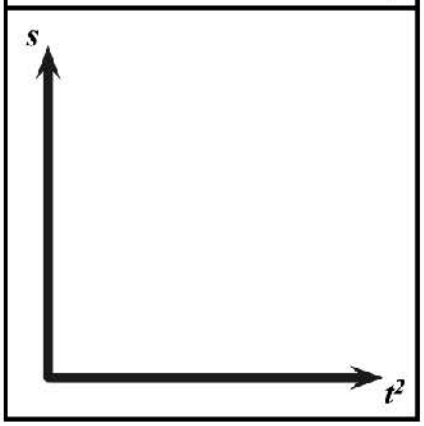
37. A block is initially at rest on a smooth horizontal table and is given a constant horizontal acceleration. Sketch the following graphs with the use of the given equations.

(a) $v = u + at$

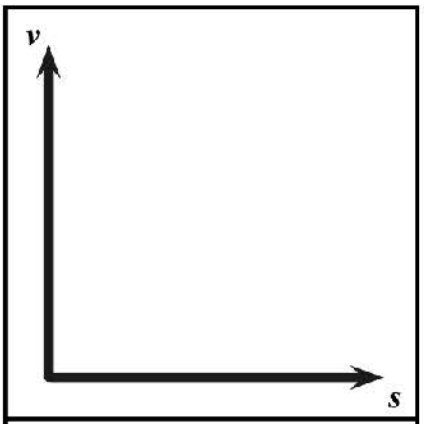


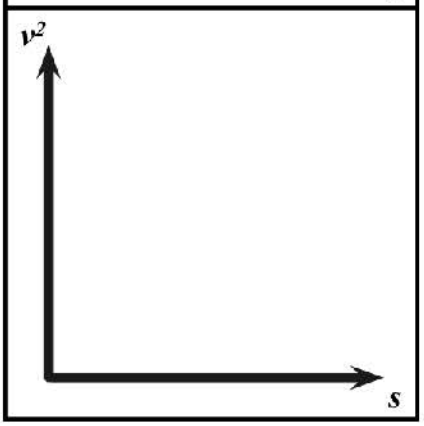
(b) $s = ut + \frac{1}{2}at^2$



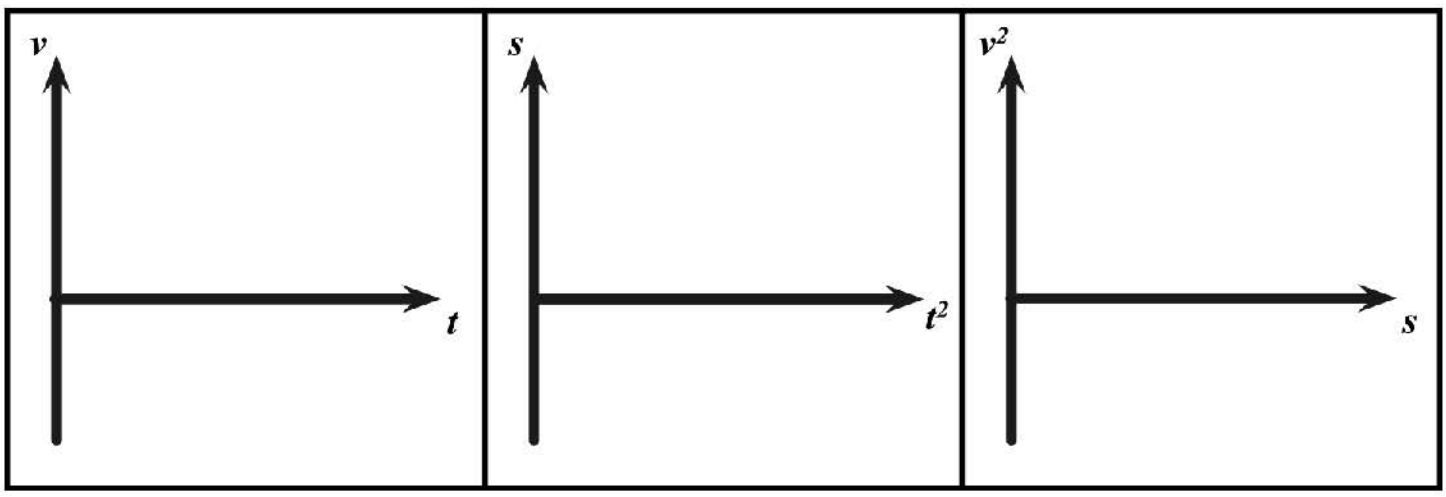


(c) $v^2 = u^2 + 2as$



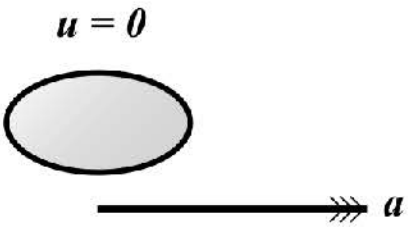


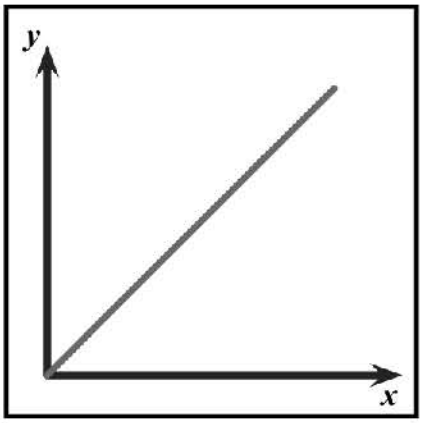
38. A block is initially moving to the right on a smooth horizontal table and is given a constant horizontal acceleration towards left. Sketch the following graphs.



Examples that you must fully understand

39. A block is initially at rest on a smooth horizontal table and is given a constant horizontal acceleration. The figure shows the relationship between the physical quantities y and x. Which of the following combination of y and x is possible?





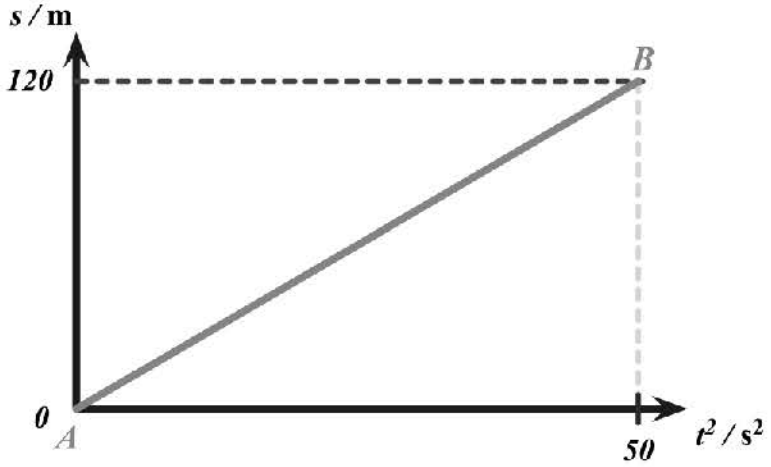
(1) y: displacement of the block; x: time

(2) y: square of velocity of the block; x: time

(3) y: velocity of the block; x: displacement

(4) y: acceleration of the block; x: time

40. The figure below shows the variation of the displacement s with the square of time t_2 for an object starting from rest along a straight line from a point A to a point B.



(a) Find the acceleration of the object.

(b) Find the velocity v_1 of the object at the midpoint of AB.

(c) Find the velocity v_2 of the object at the time instant of half the journey.