Delta Science Education

Billy Li

HKDSE Physics

Core 2: Force and Motion

Chapter 1: Position and Movement

Part 1

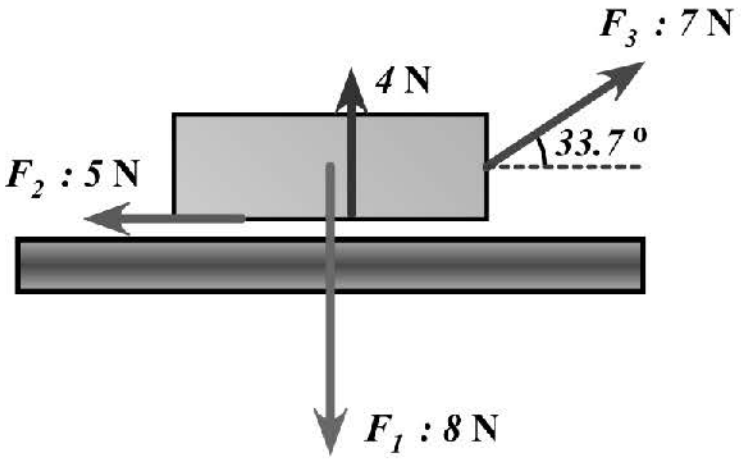
直接 Whatsapp Billy sir: 9341 0473

1. Vector

(1) Physical Quantities

Scalar	Vector
• Examples: temperature (K), time (s), distance (m), volume (m^3), frequency (Hz), mass (Kg), length (m), area (m^2)…and money	• Examples: force (N), displacement (m), velocity (m s^{-1}), acceleration (m s^{-2}), momentum (Kg m s^{-1})…

(2) The Basic of Vectors



- A vector = magnitude + direction:

  F_1 = 8 N (downwards);

  F_2 = 5 N (leftwards);

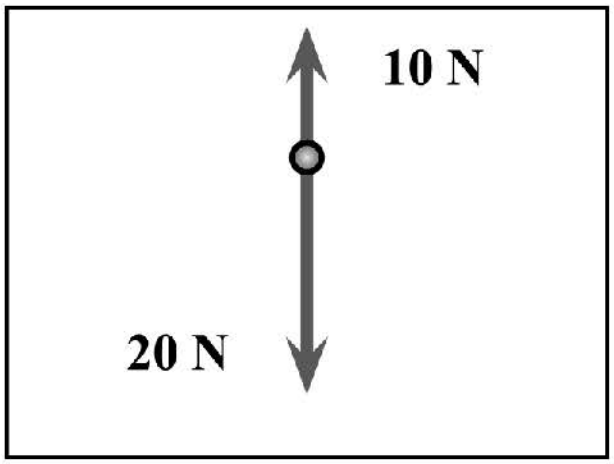
  F_3 = 7 N (N56.3°E)

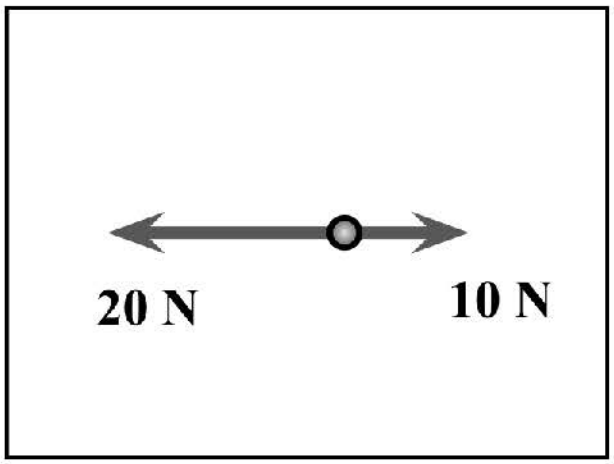
- Vector quantities in an equation should be indicated by adding an arrow over a letter or by bolding a letter:

$$E = mc\Delta T \qquad \vec{F} = m\vec{a} \qquad \mathbf{p} = m\mathbf{v} \qquad \mathbf{s} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$$

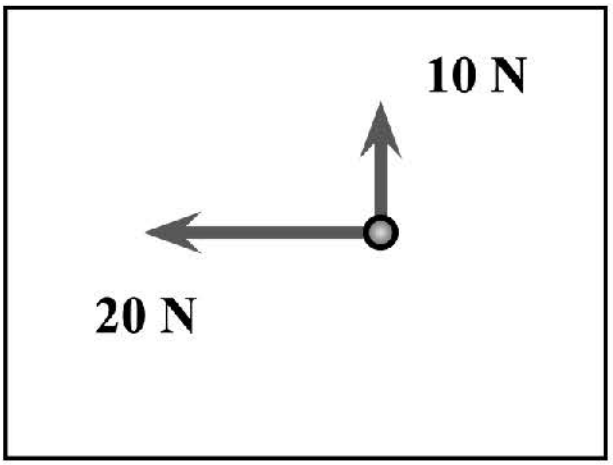
(3) Direction of Vectors

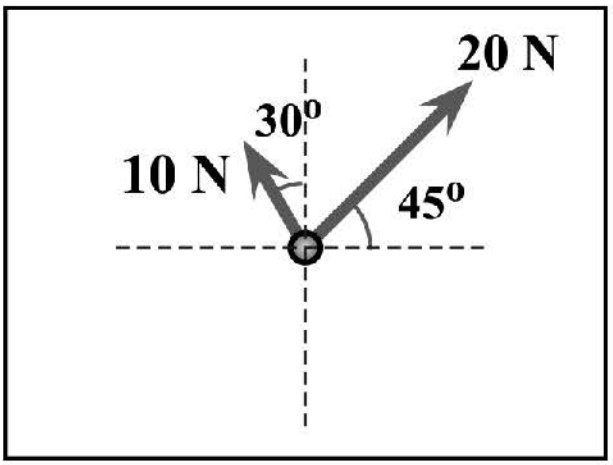
1-D situation





2-D situation





Examples that you must fully understand

1. Arrange the following quantities in ascending order:

-27, 10, -20, 0, 40, 79, -5, 20

(a) If the above quantities are temperature:

(b) If the above quantities are force:

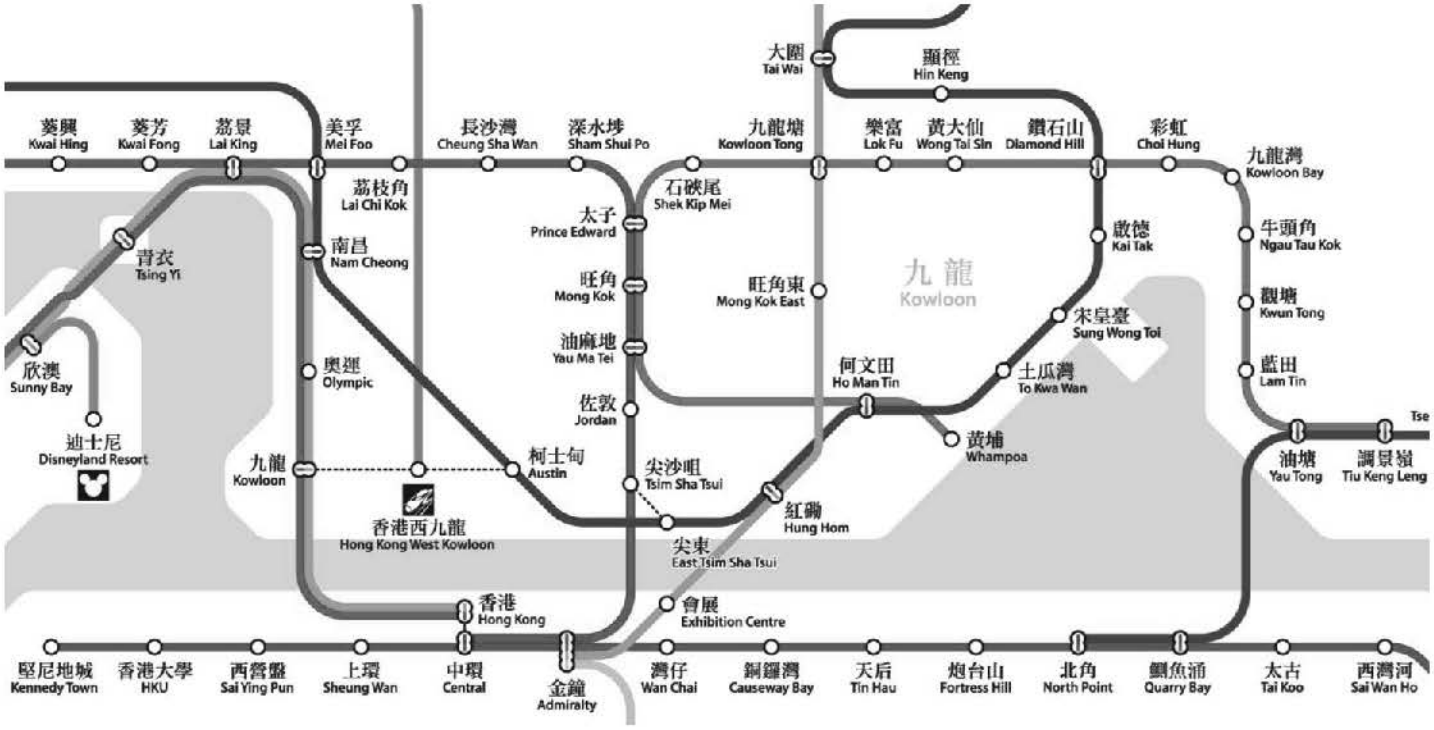
2. Quantities related to motion

(1) Time (t)

- Time describes how long a motion/event lasts.
- Time is a scalar quantity.
- Units of time can be second (s), millisecond (ms), minute (min), hour (h), day, month, year.
- Time can be measured by stop-watch, clock or ticker-tape timer.

(2) Distance and Displacement (s)

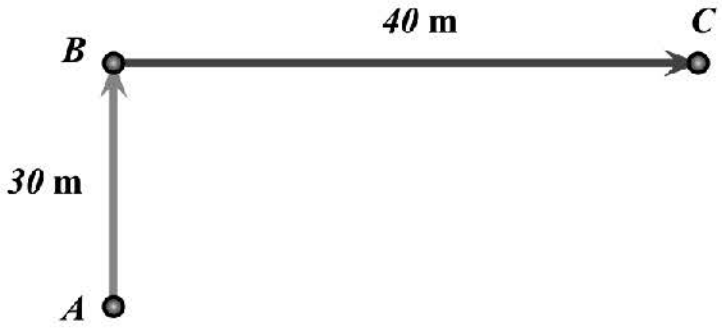
Distance (travelled)	Displacement (s)
• Scalar	• Vector
• Distance travelled is the total length of the distance that the object has **actually gone** through. • Distance depends on the actual path taken to move from the starting to the ending point.	• Displacement is the [ ] distance between the starting point to the ending point. • Displacement is independent of the actual path taken.
• Units are meter (m), millimeter (mm), centimeter (cm), kilometer (km)	



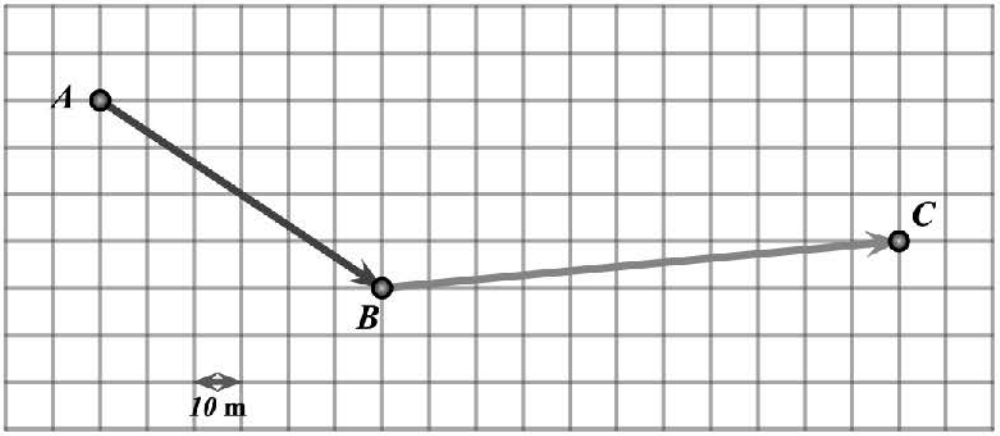
Examples that you must fully understand

2. A space shuttle flew round the Earth 14 times in a circular orbit. The radius of the circular orbit is 6,740 km from the centre of the Earth. Calculate both the distance travelled and the displacement of the space shuttle.

3. Mary walked from point A to B and then to C as shown in the figure below. Calculate both the distance travelled and the displacement of her.

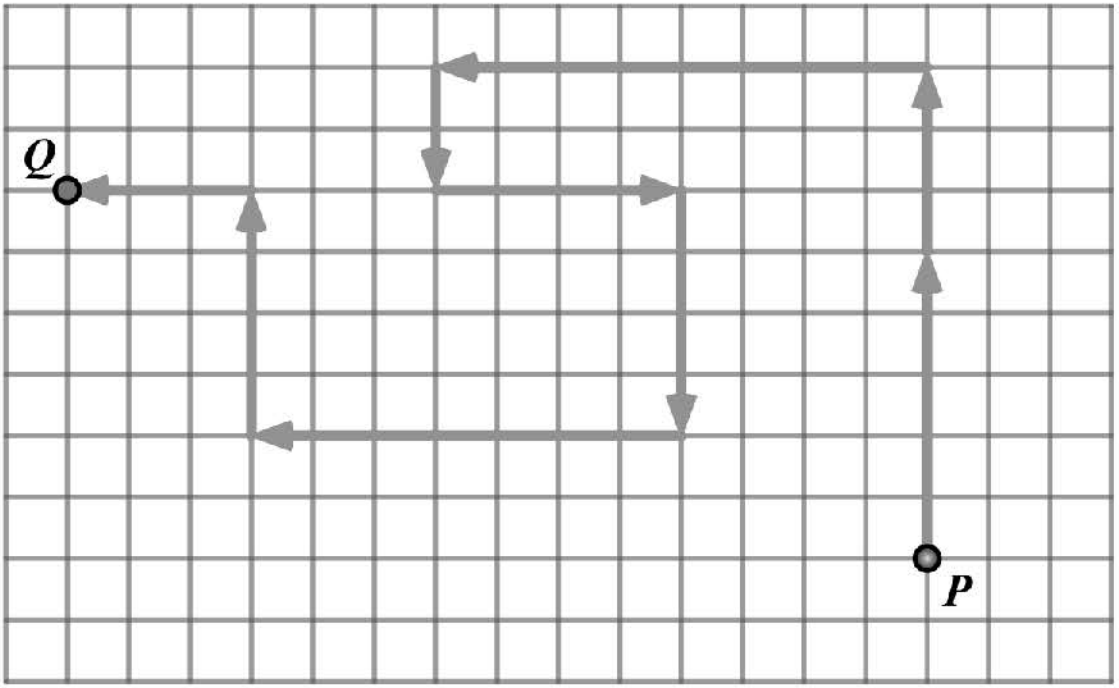


4. John walked from point A to B and then to C as shown in the figure below. Calculate both the distance travelled and the displacement of her.



Examples that you must fully understand

5. Billy was walking from point P to point Q. The map below shows his path taken. Find the total distance travelled and total displacement of his journey. The length of the side of each square is 1 m.



6. Suppose John has moved from point X to point Y. Which of the following statement(s) is / are correct?

(1) The displacement of his journey maybe greater than the distance travelled of his journey.

(2) Only when he travelled in a straight line from point X to point Y will his displacement equal his distance travelled.

7. Mary and Michael start moving from the same point. Mary walked 100 m due North while Michael walked 100 m due West. Which of the following statement(s) is / are correct?

(1) Both of them have the same displacement counted from the starting point.

(2) Both of them have the same magnitude of displacement counted from the starting point.

(3) Both of them have the same distance travelled.

(3) Speed (u, v) and Velocity (u, v)

■ Speed and velocity are describing the movement of an object:

Speed, u, v	**Velocity, u, v**
• Scalar	• Vector
• = rate of change of **distance** • = the distance changed in one second	• = rate of change of ☐ • = the displacement changed in one second
• Units are meter per second (m s^{-1}), km h^{-1} $1\ \text{km h}^{-1}$	

Average velocity (or speed)	Instantaneous velocity (or speed)
$v = \frac{\Delta s}{\Delta t}$	
• **The time period is over a ☐ period of time.** $\bar{v} = \frac{Total\ Displacement}{Total\ Time}$	• **The time period is over a ☐ period of time.** $v = \frac{\Delta s}{\Delta t}$

Examples that you must fully understand

8. Calculate the average speed and average velocity of **Billy** of Example 5 on page 6. Suppose Billy took 10 s to complete the journey.

Examples that you must fully understand

9. Mr Wong takes 40 s to run 150 m from P to Q along a straight road and then takes 70 s to run 100 m from Q to R. Calculate the average speed of Mr Wong during:

(a) the journey from P to Q;

(b) the journey from Q to R;

(c) the whole journey

10. A ship sails due north with a speed of 20 m s^{-1} for 5 minutes and then due east with a speed of 30 m s^{-1} for 4 minutes. What is the average speed and average velocity for the whole journey?

11. Judy walks along a straight road from point X to Y with an average speed of 4 m s^{-1}. She then returns to point X along the same road with an average speed of 6 m s^{-1}. What is her average speed and average velocity for the whole journey?

Examples that you must fully understand

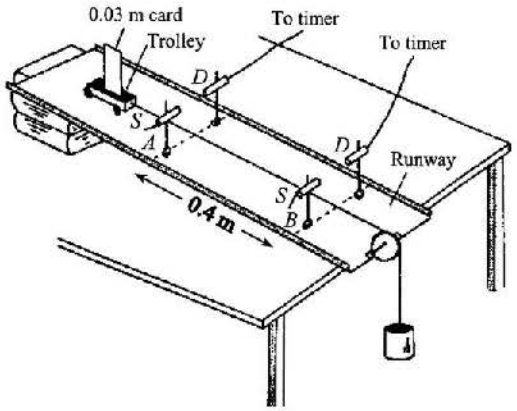
12. The following table shows the position of a body from a fixed point P along a straight line at different time instants.

Time instant t / s	Distance from P x / m
0	10.0
1.8	19.2
1.9	19.6
2.0	20.0
2.1	20.8
2.2	21.0
2.9	31.9
3.0	32.0
3.1	32.4
4	40

(a) What is the average velocity of the whole journey?

(b) What is the instantaneous velocity at t = 2 s?

13. The figure shows a trolley running down a friction compensated runway. Acard of width 0.03 m is attached to the trolley. Light sources S and light detectors D are fixed at two positions A and B along the runway. Each light dector is connected to a timer, which can measure the time taken by the card to pass the light detector.



The timers record that it takes 0.050 s and 0.025 s for the card to pass the light detectors at A and B respectively. Calculate the speed of the trolley as it passes position A, and position B. Thus calculate the average speed from A to B if it takes 0.44 s to move from A to B.

Examples that you must fully understand

14. A runner finishes a 100 m race in 9.9 s. When he passes the final point, a digital sensor records he moves a distance of 0.3 m in 0.015 s.

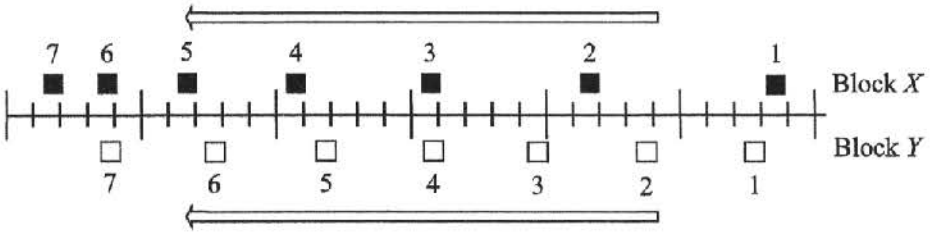
(a) Find the average speed.

(b) Find the average velocity.

(c) Find the instantaneous speed at the moment he starts running.

(d) Find the instantaneous speed as he passes the final point.

15. Two blocks X and Y are moving towards left. Their positions at successive instants (indicated by the numbers) of equal time intervals are shown below.



Do these two blocks ever have the same instantaneous speed ?

A. *Yes, at instant 3.*

B. *Yes, at a moment between instants 4 and 5.*

C. *Yes, at instant 6.*

D. *No.*

16. The speedometer of a car indicates the car's

A. *instantaneous velocity.*

B. *instantaneous speed.*

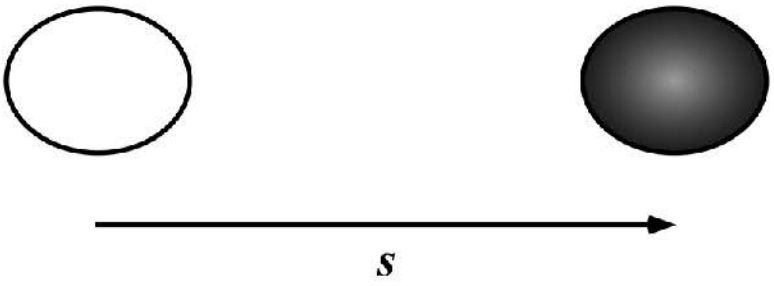
C. *average speed of the whole journey.*

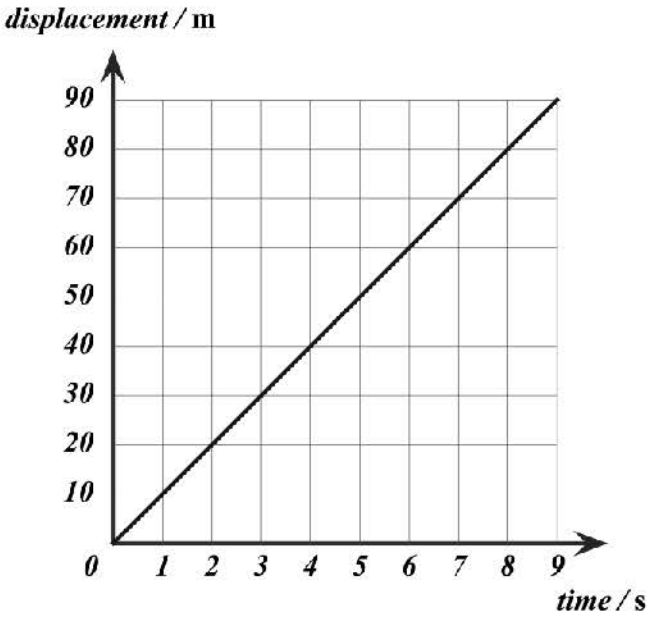
D. *average velocity of the whole journey.*

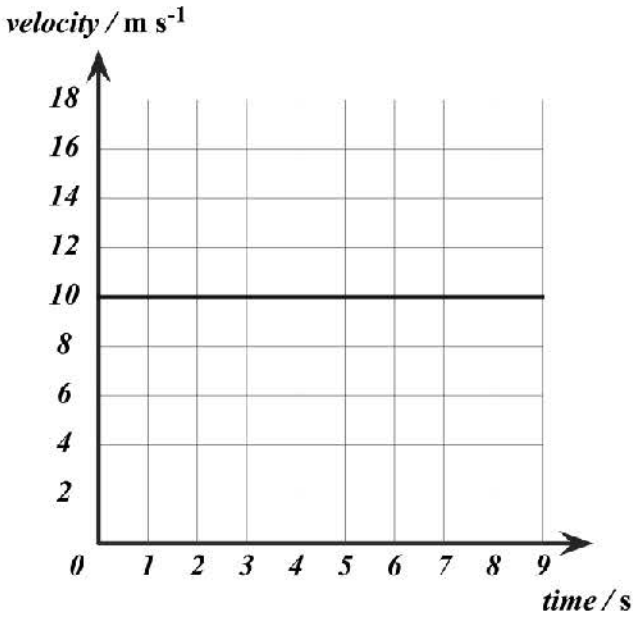
- **Uniform motion** = there is **no change in the** ☐ of a body.
- The motion is not uniform if there is:
  - **change in** ☐
  - **change in** ☐
- Uniform motion equation:

☐

- Graphical representation of uniform motion:

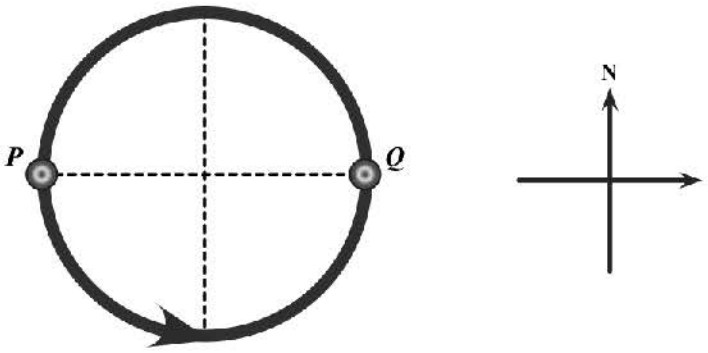






Examples that you must fully understand

17. A car moves along a circular track from P to Q as shown. At Q, the speedometer shows a reading of 100 km h^{-1}.



Which of the following statements is / are correct?

(1) The speedometer's reading is the average speed of the whole journey.

(2) The speedometer can tell us the instantaneous velocity of the car.

(3) The velocirty of the car at point Q is 100 km h^{-1} due North.

(4) The average speed is the same as the average velocity of the car when it moves from P to Q.

(5) When the car is at Q, its displacement has the same direction as its instantaneous velocity.

(6) The car is in uniform motion.

(7) Suppose the reading of speedometer does not change from P to Q, the car's (instantaneous) velocity does not change.

18. It takes 8 minutes 20 seconds for the light from the Sun to reach the Earth. Given that the speed of light in vacuum is 3×10^8 m s^{-1}, what is the distance between the Earth and the Sun?

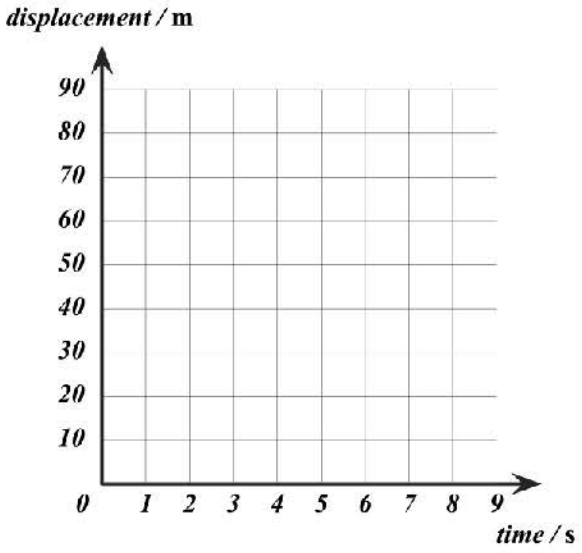
19. Barry and Robin run along a straight road from point P to point Q. The velocity of Barry is v_1 and that of Robin is v_2. If Barry reaches Q at a time T before Robin, what is the distance between P and Q?

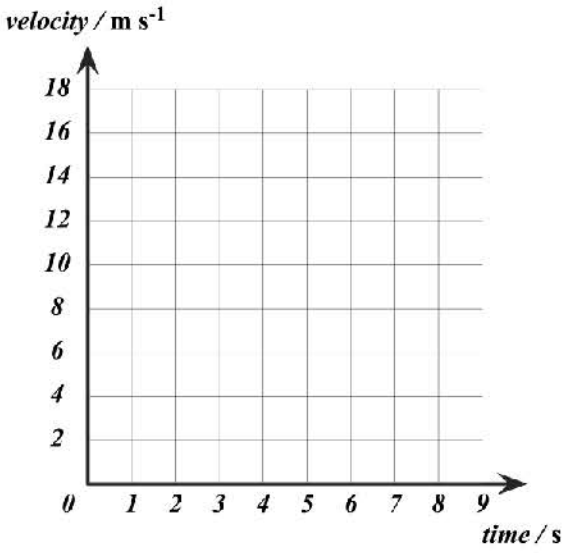
Examples that you must fully understand

20. Maurice runs along a straight road. He first runs with an average velocity v_1 in a time interval t_1, and then runs with another average velocity v_2 in the next time interval t_2. What is her average velocity in the whole journey?

21. Sketch the displacement-time graph and the velocity-time graph of Judy and Mavis, according to the information given below:

Judy walks with uniform motion along a straight line. She takes 8 seconds to move 40 m. Mavis walks with a uniform velocity of 15 m s^{-1} for 6 seconds. Both of them start at the same point.





22. 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?

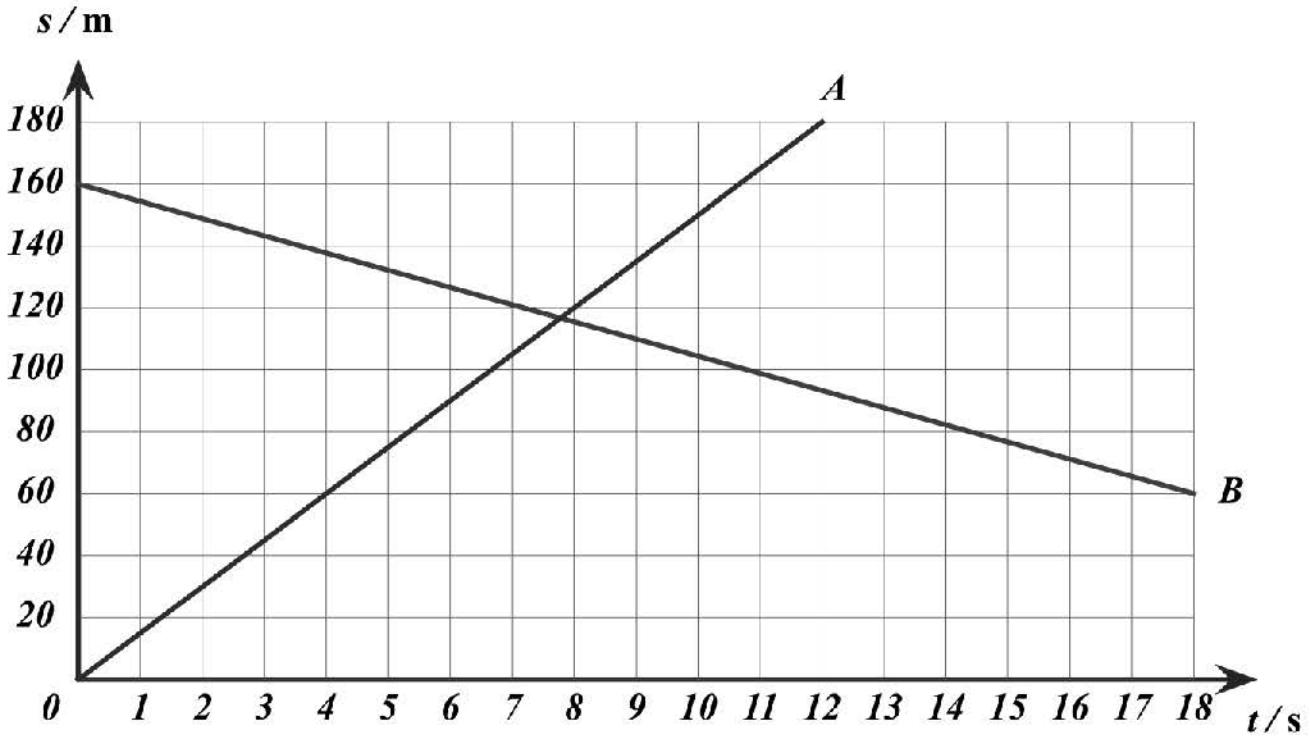
(1) The displacement of the body from the starting point increases uniformly.

(2) The body moves with uniform velocity.

(3) The body moves with uniform acceleration.

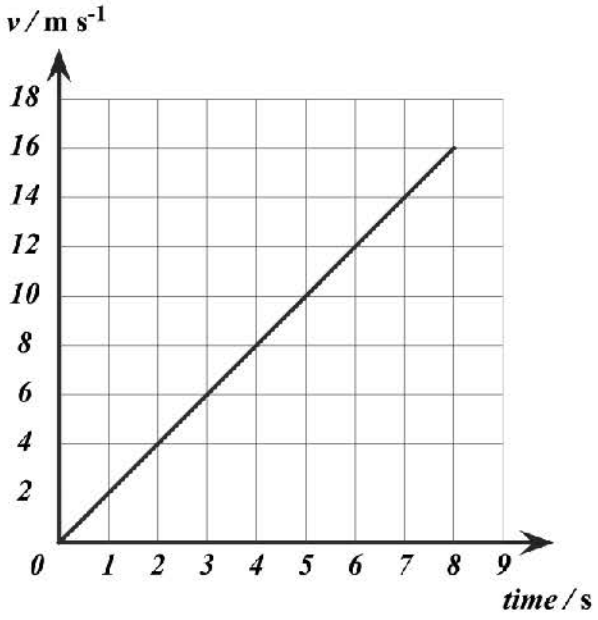
Examples that you must fully understand

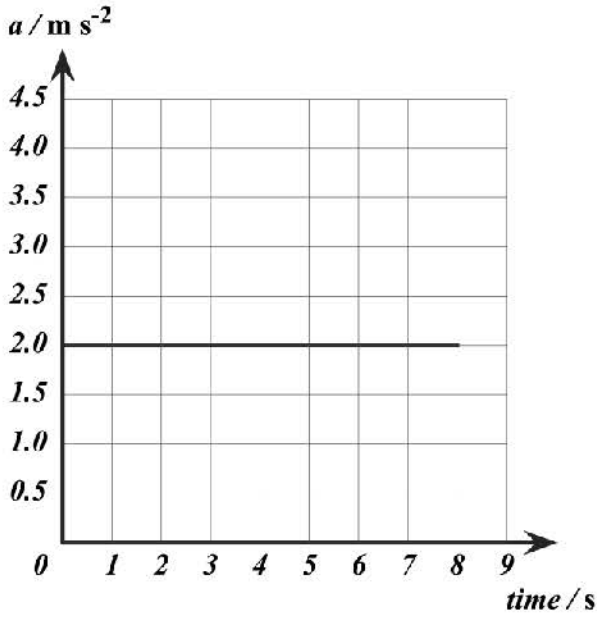
23. The *s-t* graphs of cars *A* and *B* are given below. Sketch their *v-t* graphs.



(4) Acceleration (a)

- Graphical representation of motion under acceleration:





- Average acceleration of an object = **rate of change in** ☐:

No acceleration	Under acceleration
• An object is ☐ **at rest** • An object is moving with **uniform velocity** (in uniform motion)	• **Speeding up** (undergoing acceleration) • **Slowing down** (undergoing deceleration / opposite acceleration) •

Examples that you must fully understand

24. Which of the following statements is / are correct?

(1) An object may be at rest but undergoes acceleration.

(2) An object may have a constant speed but undergoes acceleration.

(3) An object may have a constant velocity but undergoes acceleration.

Examples that you must fully understand

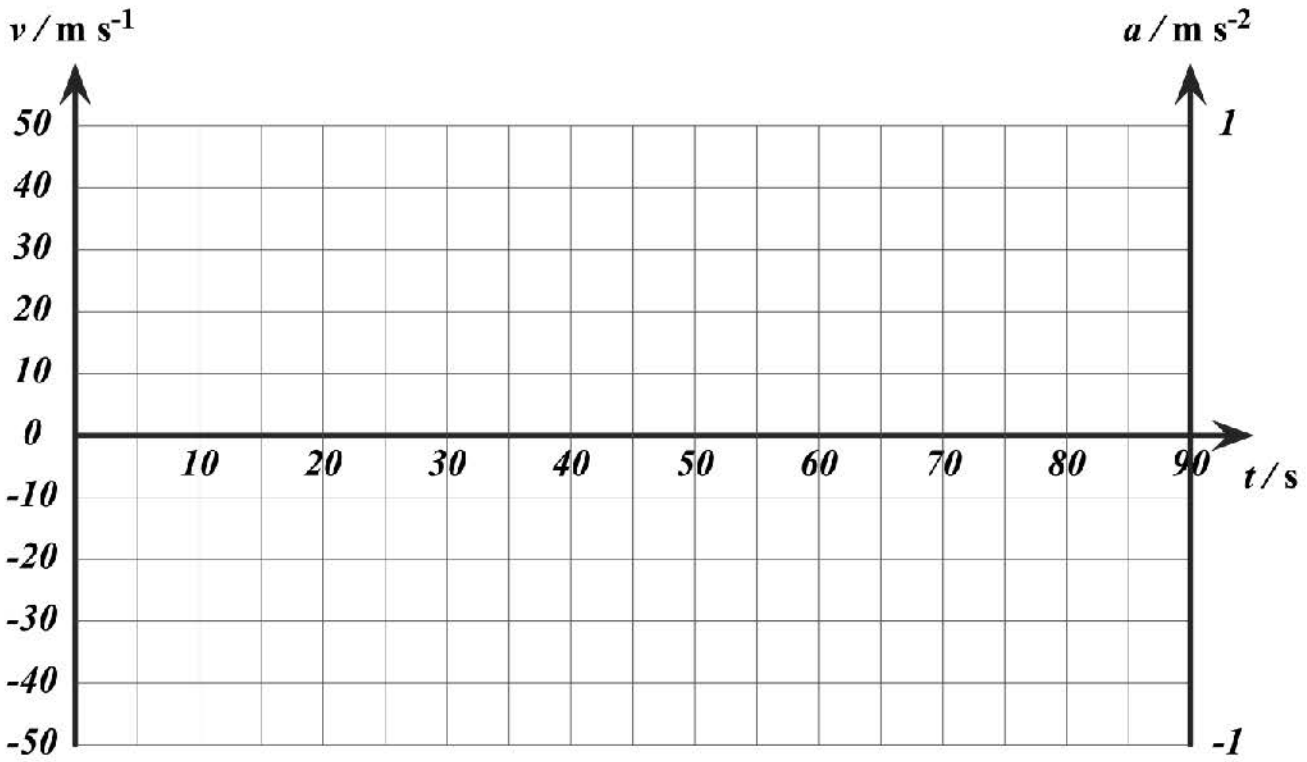
25. A car undergoes uniform deceleration along a straight road. Its velocity decreases from 30 m s^{-1} to 20 m s^{-1} after travelling 15 s.

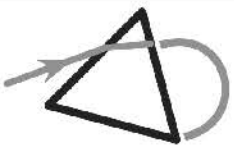
(a) How long further will the car travel before it comes to a rest?

(b) If the car keeps the same acceleration for 30 s, what will be the velocity of the car?

(c) If the car keeps the same acceleration for another 15 s, what will be the velocity of the car?

(d) Sketch the v-t and a-t graphs.



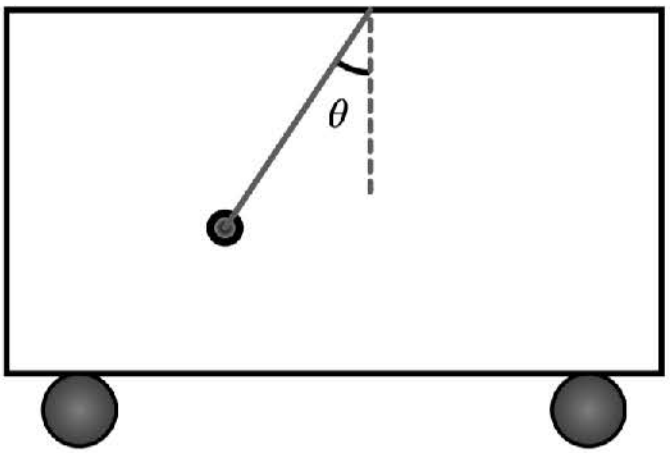


- Acceleration is a vector, it has the same direction as "change in velocity":

	Situation	Direction of u	Direction of Δv/a/	Speeding up/slowing down	Acceleration or deceleration?
(i)	A body is moving forward with increasing speed.			Speeding up	
(ii)	A body is moving forward with decreasing speed.			Slowing down	
(ii)	A body is moving backward with increasing speed.			Speeding up	
(iv)	A body is moving backward with decreasing speed.			Slowing down	

Examples that you must fully understand

26. A ball is hung by a string from the ceiling of a bus. At a certain instant, the ball itself becomes inclined as shown in the figure. Which of the following descriptions about the motion of the bus is / are possible?



(1) It is moving to the right with constant velocity.

(2) It is at rest.

(3) It is moving to the right and accelerating.

(4) It is moving to the left and decelerating.

(5) It just starts to move to the right from rest.

Examples that you must fully understand

27. Which of the followings must be in the same direction?

(1) Displacement and velocity

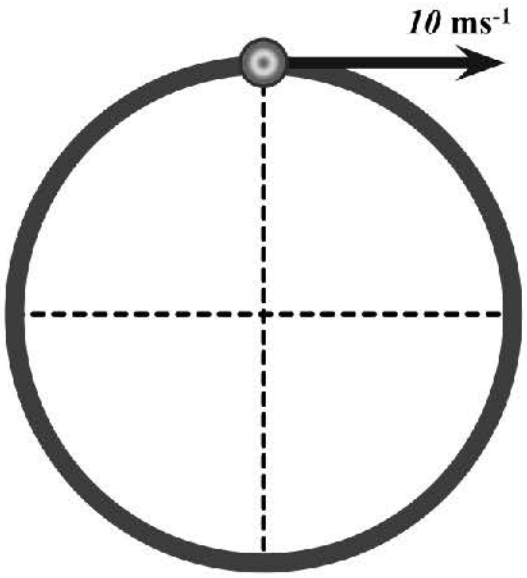
(2) (Total) displacement and average velocity

(3) Velocity and acceleration

(4) Change in velocity and acceleration

(5) Net force and acceleration

28. A car enters a traffic circle with a velocity of 10 m s^{-1}. Assume that the car travels with uniform speed throughout the circle. Someone says, "*Since the speed of the car is always 10 m s^{-1}, there is no acceleration acting on the car.*" Is he correct?

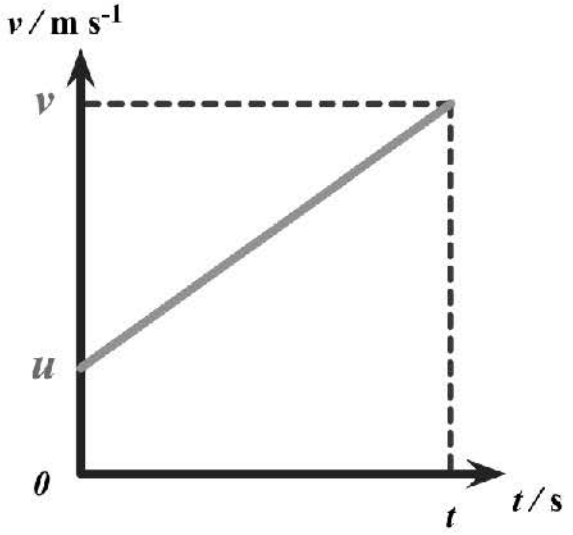


He is [ ]. ***Although the*** [ ], ***the*** [ ] [ ] ***with time. There must be an*** [ ] ***acting on the car.***

29. A particle moving along a straight line with speed 0.5 m s^{-1} changes its direction of motion within a period of 0.2 s and subsequently travels with the same speed in the opposite direction. Find the magnitude of its average acceleration during this time period of 0.2 s.

3. Equations of Uniformly Accelerated Motion

(1) Derivation of the equations



1. $a=\frac{v-u}{t} \Rightarrow v=u+at$

2. $s=(\frac{u+v}{2})t$

3. $s=(\frac{u+v}{2})t=(\frac{u+(u+at)}{2})t=ut+\frac{1}{2}at^2$

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

(2) The four equations

$s=ut+\frac{1}{2}at^2$	$v=u+at$	$v^2=u^2+2as$	$s=\frac{1}{2}(u+v)t$
Conditions	The four equations can only be applied on systems where: • the motion must be along a [ ] (straight line motion) • the acceleration of the system is a [ ]		

Examples that you must fully understand

30. A car accelerates from rest to a speed of 360 km h^{-1} in 10 s along a straight road.

(a) What is the acceleration of the car?

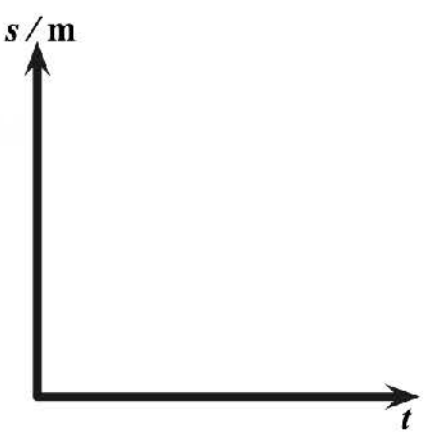
(b) What is the displacement of the car during the acceleration?

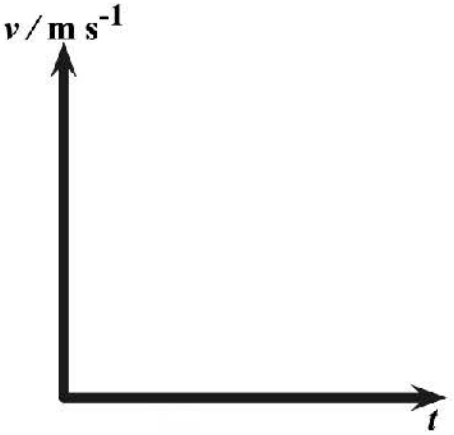
(c) After the car reaches the speed of 360 km h^{-1}, it keeps this speed and travels for 20 minutes. Calculate the displacement of the car during this period of time.

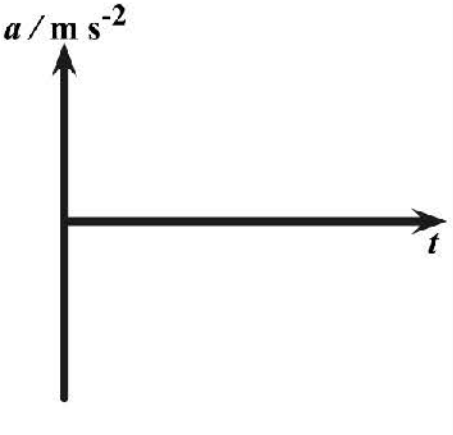
(d) After the 20 minutes in part (c), the driver sees a girl at 100 m away. What should be the deceleration of the car so that the car can just stop in front of the girl? You can assume the reaction time of the driver is 0.2 s.

The deceleration of the car is ☐.

(e) Sketch the s-t, v-t and a-t graphs, starting from the moment the driver sees the girl. You can assume the displacement to be zero when the driver sees the girl.







Examples that you must fully understand

31. Mr Fung walks along a straight road from rest with an acceleration of 6 m s^{-2} for 30 s. He then runs with an acceleration of 12 m s^{-2} for another 20 s.

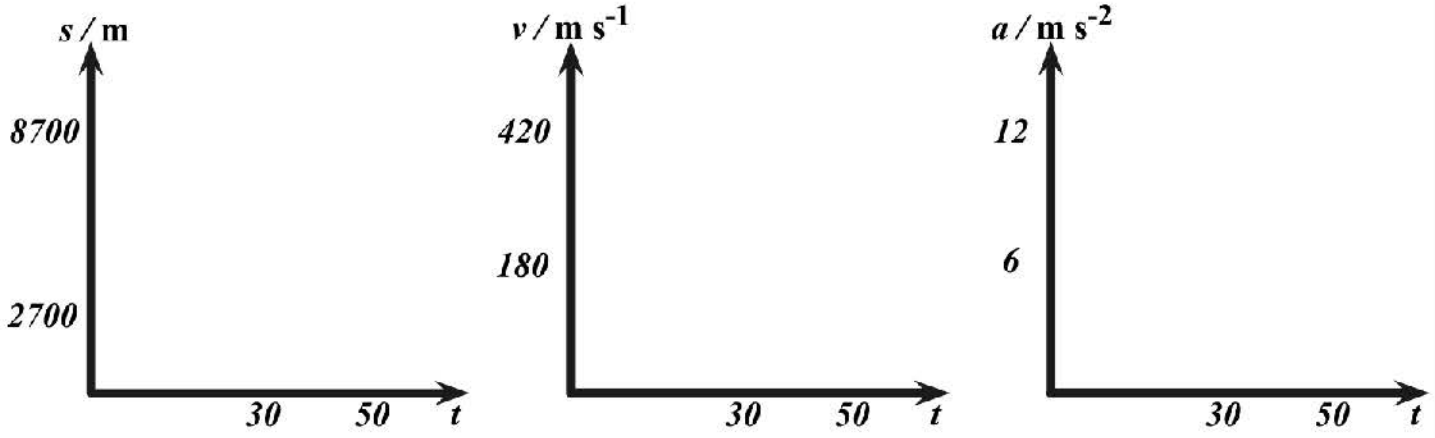
(a) Find the distance travelled during his walk.

(b) Find the final velocity when he finishes running.

(c) Find his average velocity of his walk.

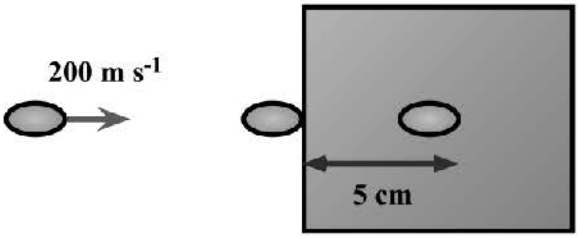
(d) Find his average velocity of the whole journey.

(e) Sketch the s-t, v-t and a-t graphs. You can assume the displacement to be zero when Mr Fung starts to walk.



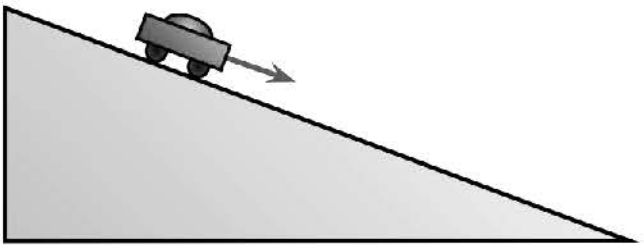
Examples that you must fully understand

32. A bullet is fired towards a nearby tree (which is 5 m from the gun) with a speed of 200 m s^{-1}. The bullet is later found at a depth of 5 cm. Find the average acceleration of the bullet inside the tree.



33. A toy car is projected with an initial velocity of 2 m s^{-1} down an inclined plane. It is found that the block travelled a distance of 5 m in 2 s.

(a) What is the acceleration of the toy car?



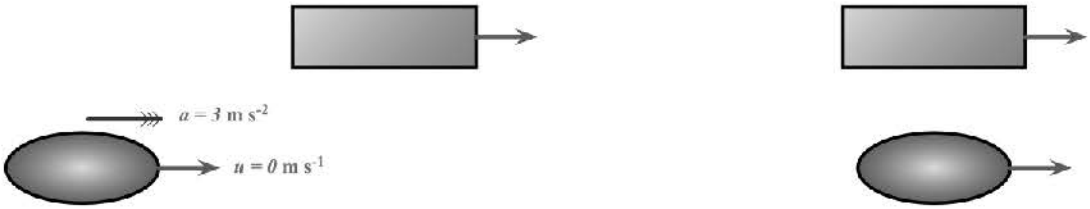
(b) How long does it take to achieve a speed of 200 m s^{-1}?

34. A car at a speed of 50 km h^{-1} can be stopped in a distance of 20 m. In what distance can the car be stopped when it is moving at a speed of 100 km h^{-1}? You can assume the stopping condition to be the same.

Examples that you must fully understand

35. An object accelerates uniformly along a straight line from X to Z. It passes X and Z with speeds 10 m s^{-1} and 20 m s^{-1} respectively. What is its speed when it passes Y, which is the mid-point of XZ?

36. A car traveling at a constant speed of 45.0 m s^{-1} passes a trooper hidden behind a billboard. One second after the speeding car passes the billboard, the trooper sets out from the billboard to catch it, accelerating at a constant rate of 3.00 m s^{-2}. How long does it take to overtake the car?



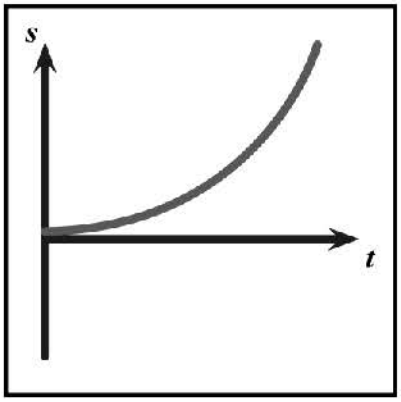
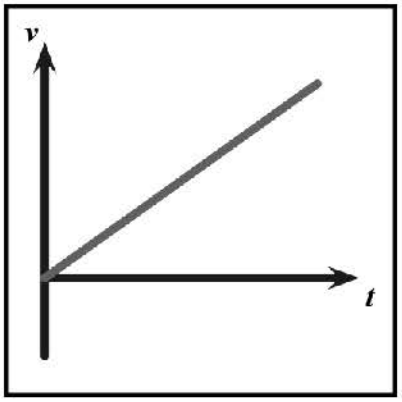
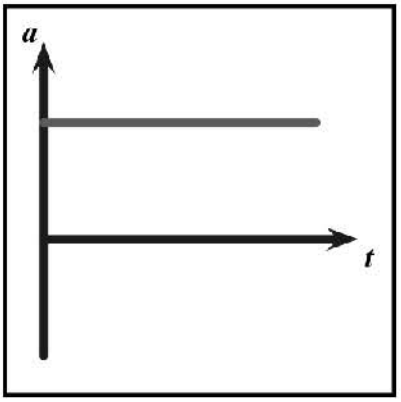
37. A truck is moving with a constant velocity of 10 m s^{-1}. A motorcycle, initially 75 m behind the truck, starts its motion from rest with a constant acceleration of 2 m s^{-1}. When will the motorcycle overtake the truck? How far is the motorcycle from the truck 2 seconds after the overtaking?

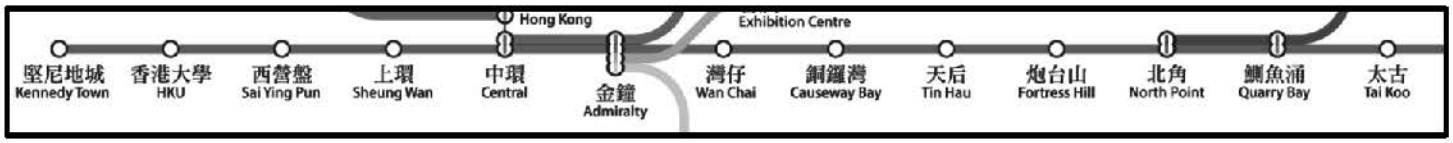
Examples that you must fully understand

38. Speedy Sue, driving at 30.0 m s^{-1}, enters a one-lane tunnel. She then observes a slow-moving van 155 m ahead traveling at 5 m s^{-1}. Sue applies her brakes but can accelerate only at –2.00 m s^{-2} because the road is wet. Will there be a collision? If yes, determine how far into the tunnel and at what time the collision occurs. If no, determine the distance of closet approach between Sue's car and the van.

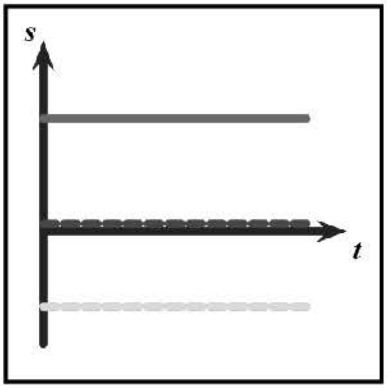
4. Graphical Representation of Motion

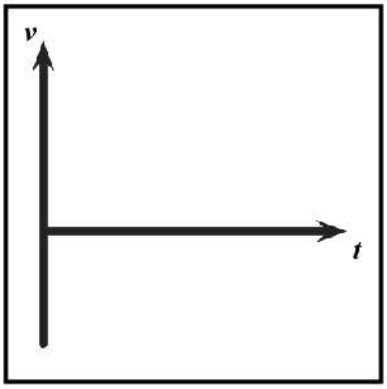
(1) Summary of the Three Motion Graphs

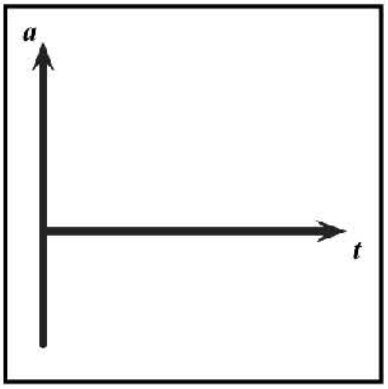
	Displacement-time	Velocity-time	Acceleration-time
			
y-axis			
x-axis			
Direct information			
Physical meaning of slope at a point			
Physical meaning of the area			

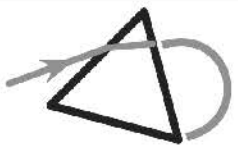


(I) Stationary

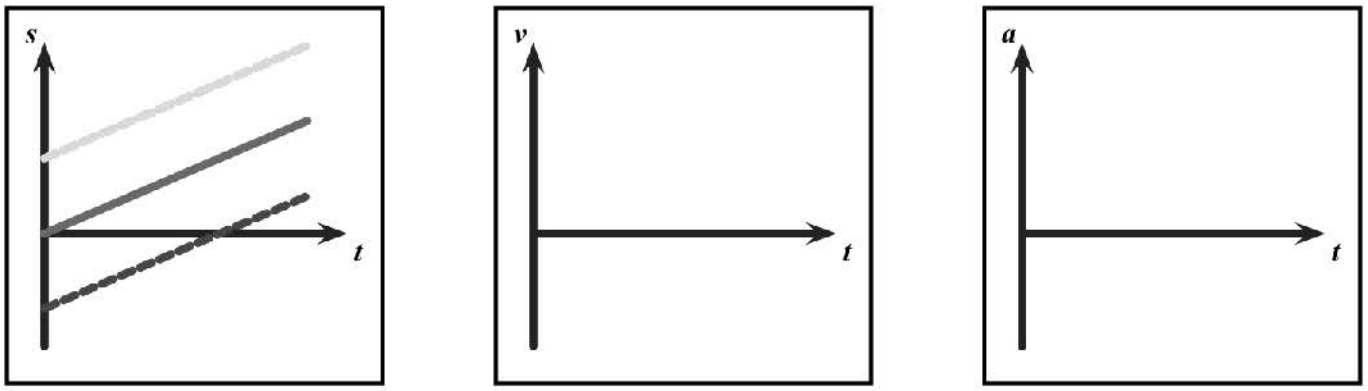




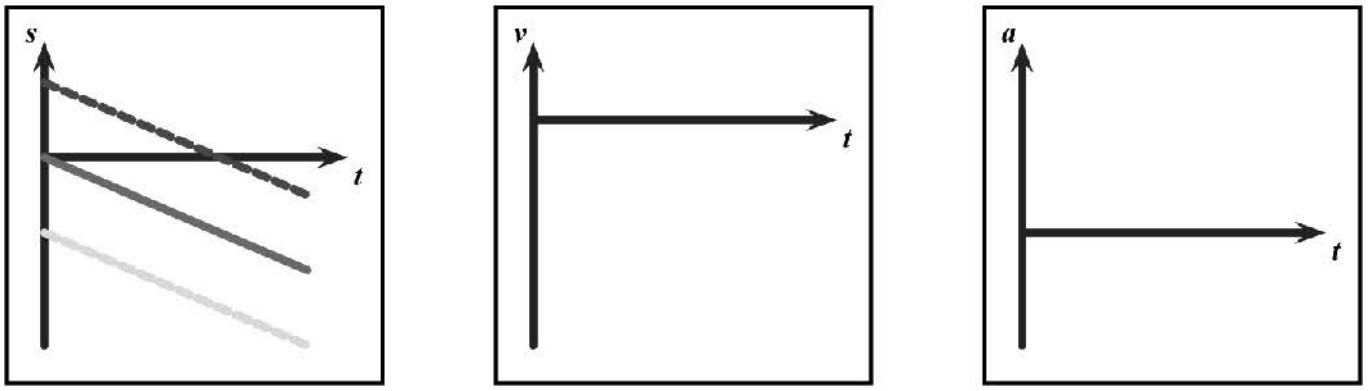




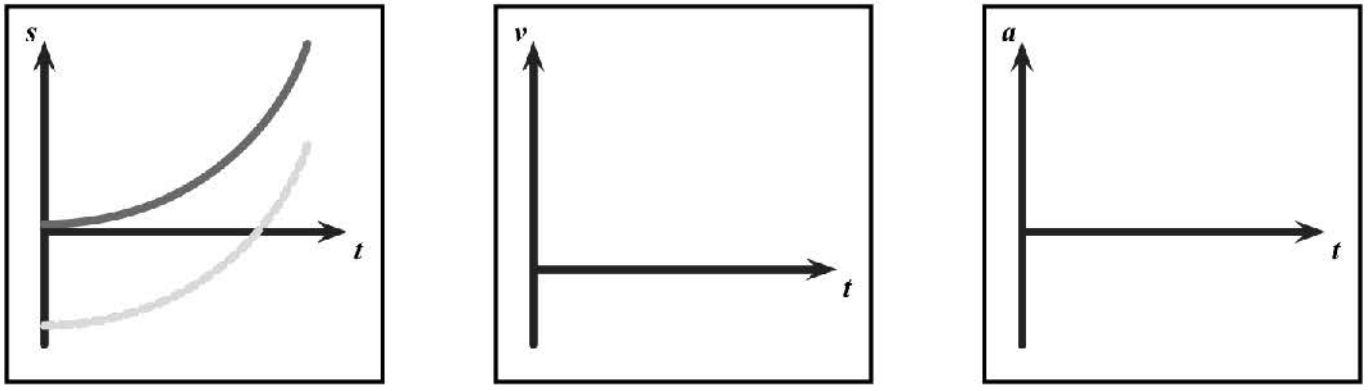
(II)a Moving forward with uniform velocity



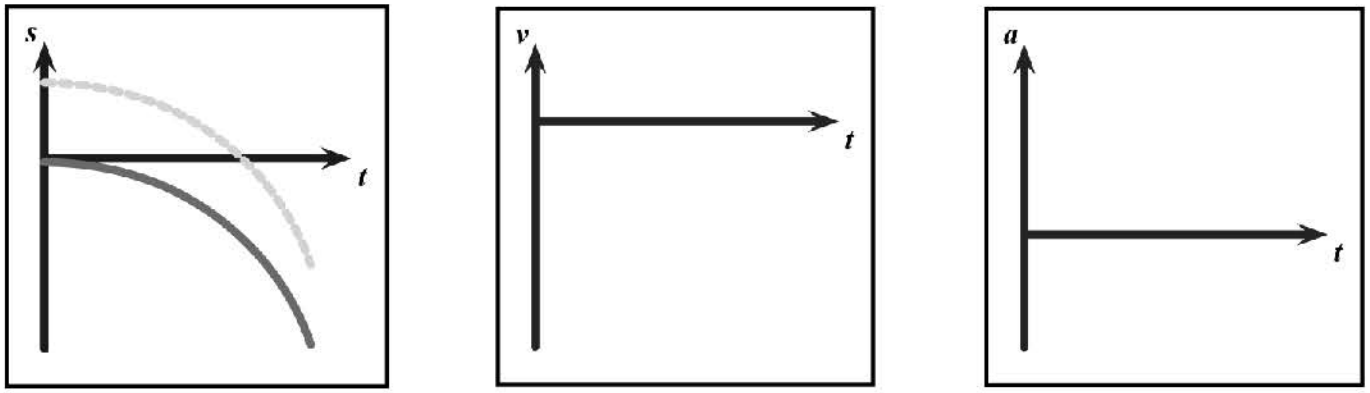
(II)b Moving backward with uniform velocity

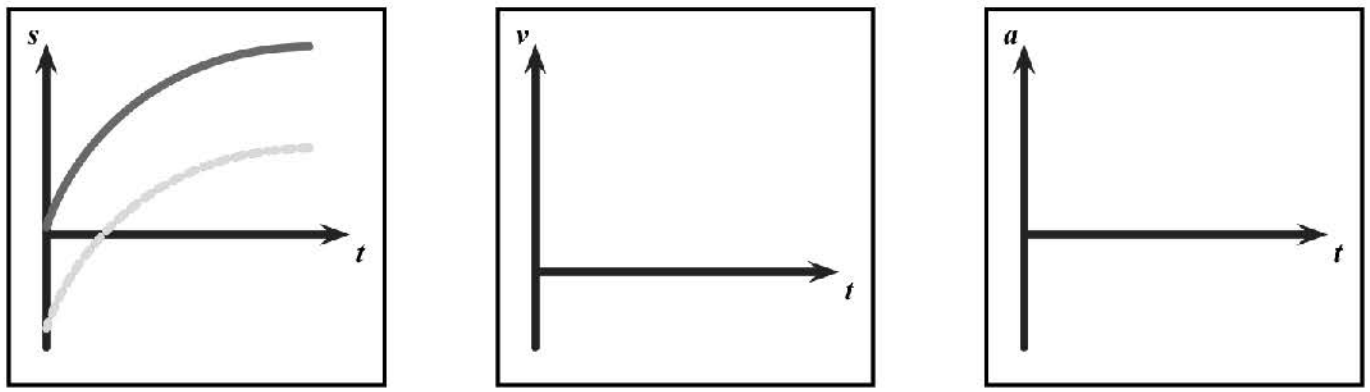


(III)a Moving forward with acceleration

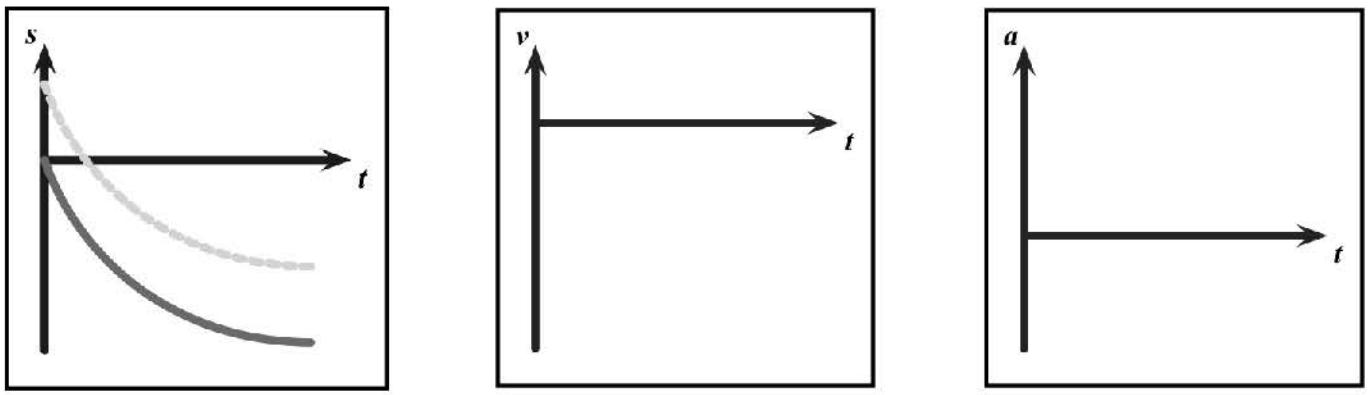


(III)b Moving backward with acceleration

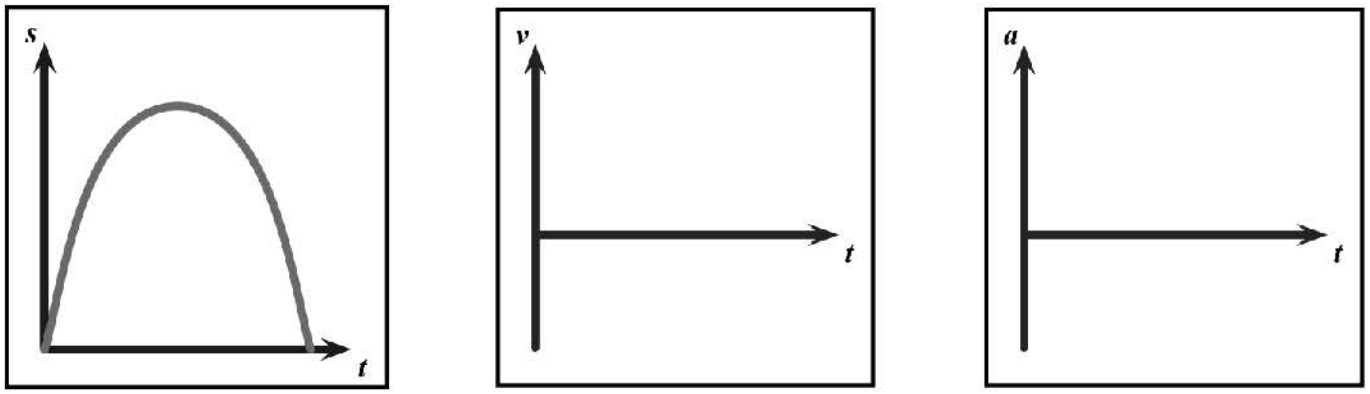




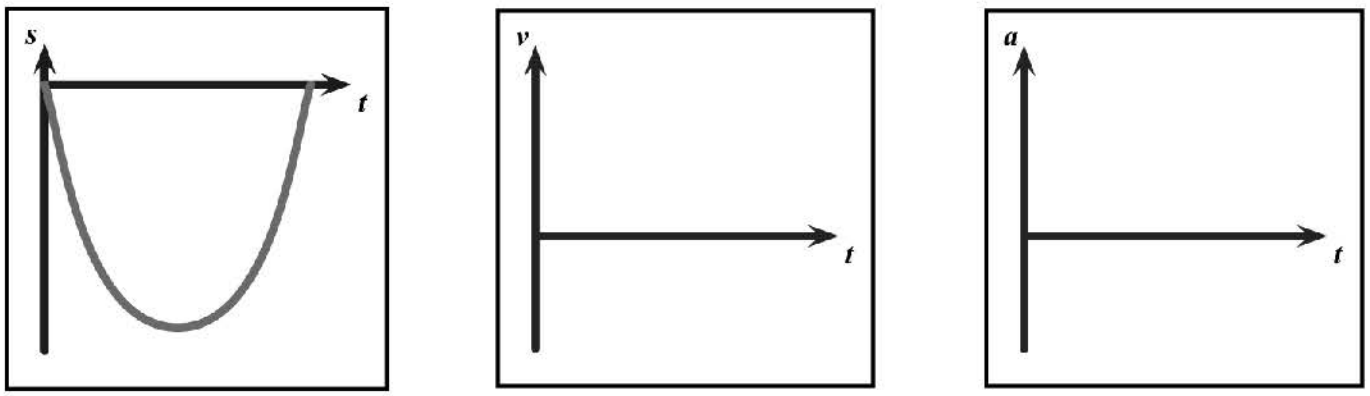
(IV)a Moving forward with deceleration



(IV)b Moving backward with deceleration



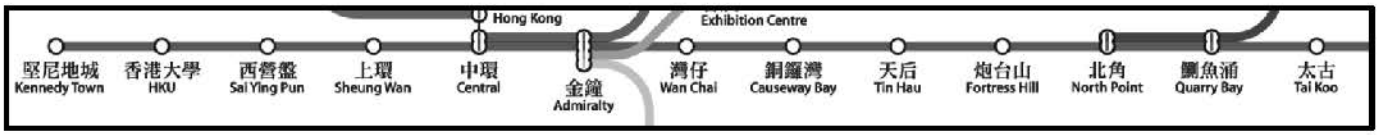
(V)a Changing direction from forward to backward

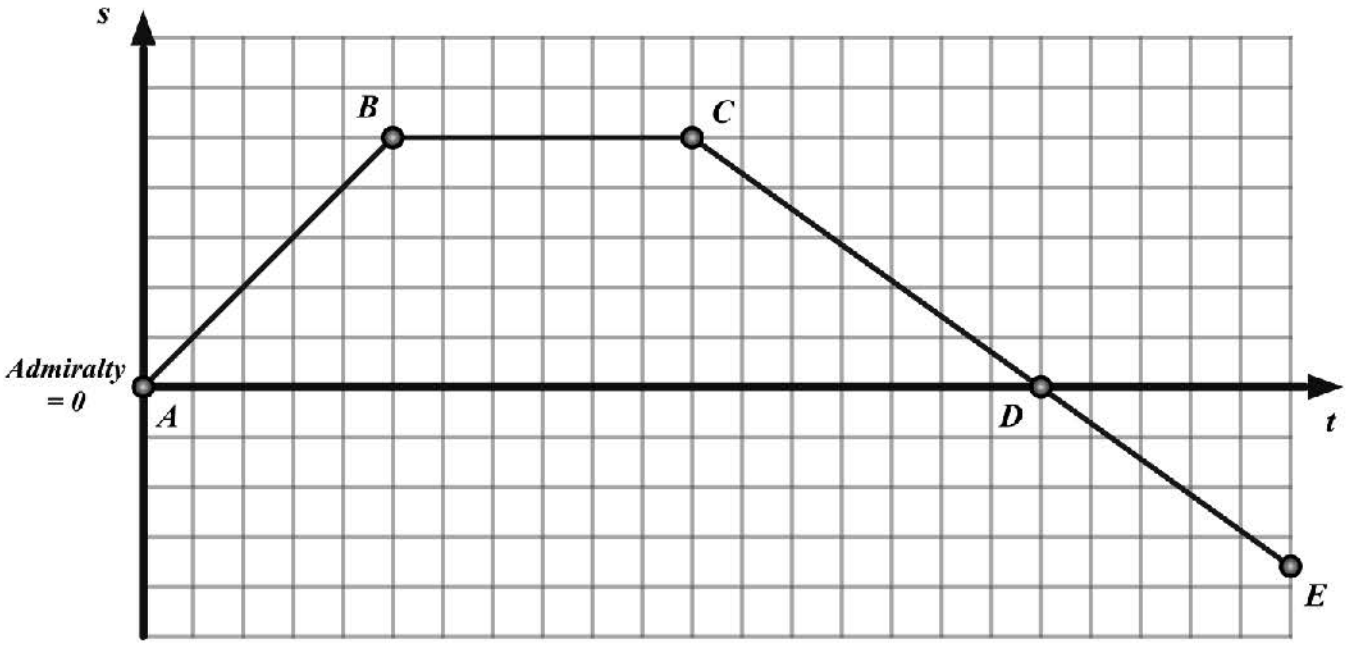


(V)b Changing direction from backward to forward

Examples that you must fully understand

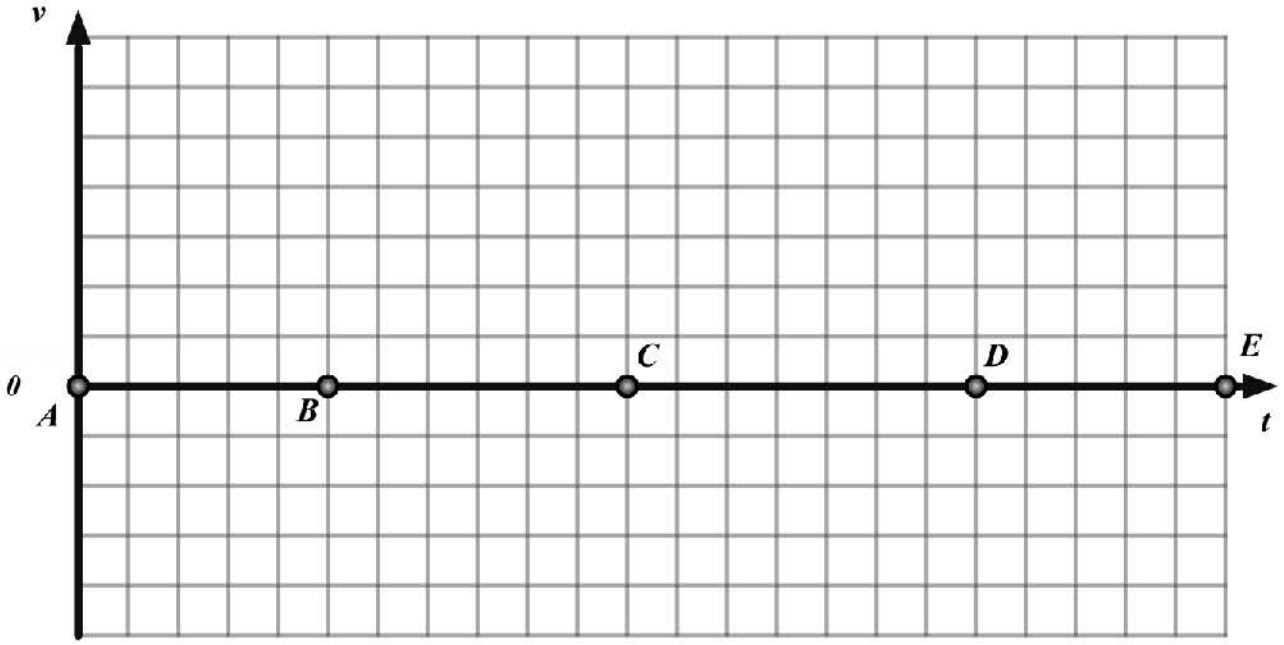
39. Below shows the map of an MTR in Island line and an *s-t* graph of the train.





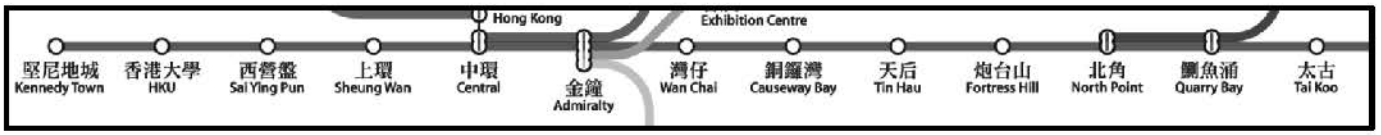
(a) Describe the train's motion.

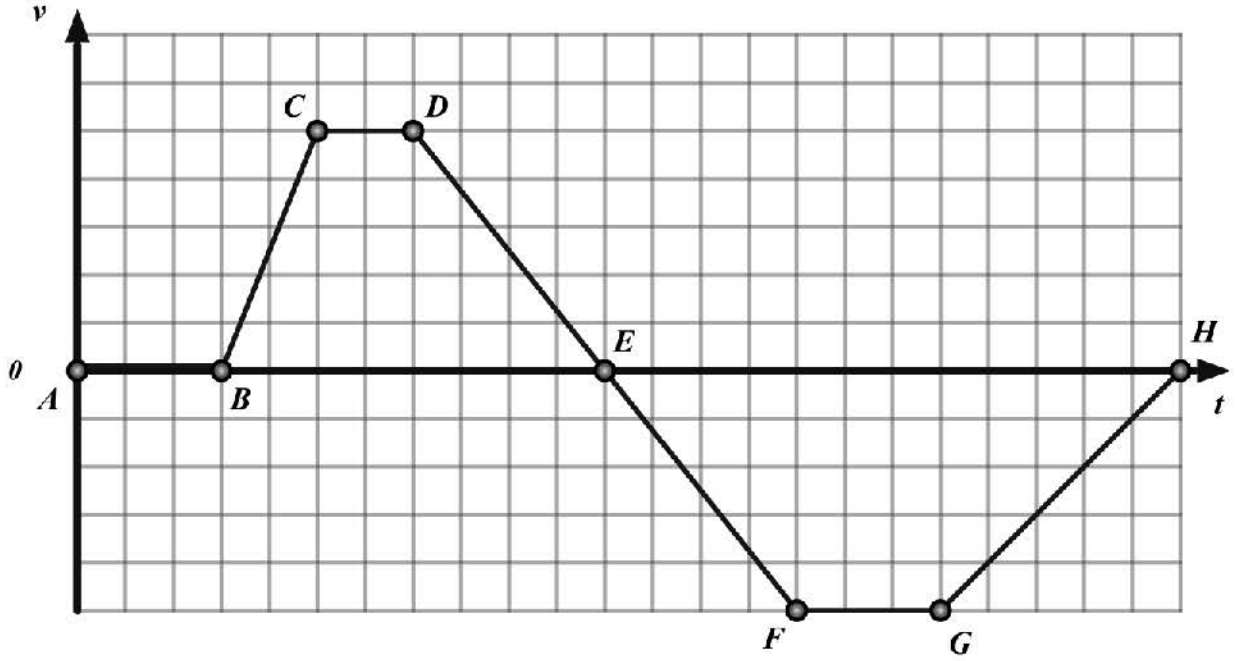
(b) Draw the v-t graph.



Examples that you must fully understand

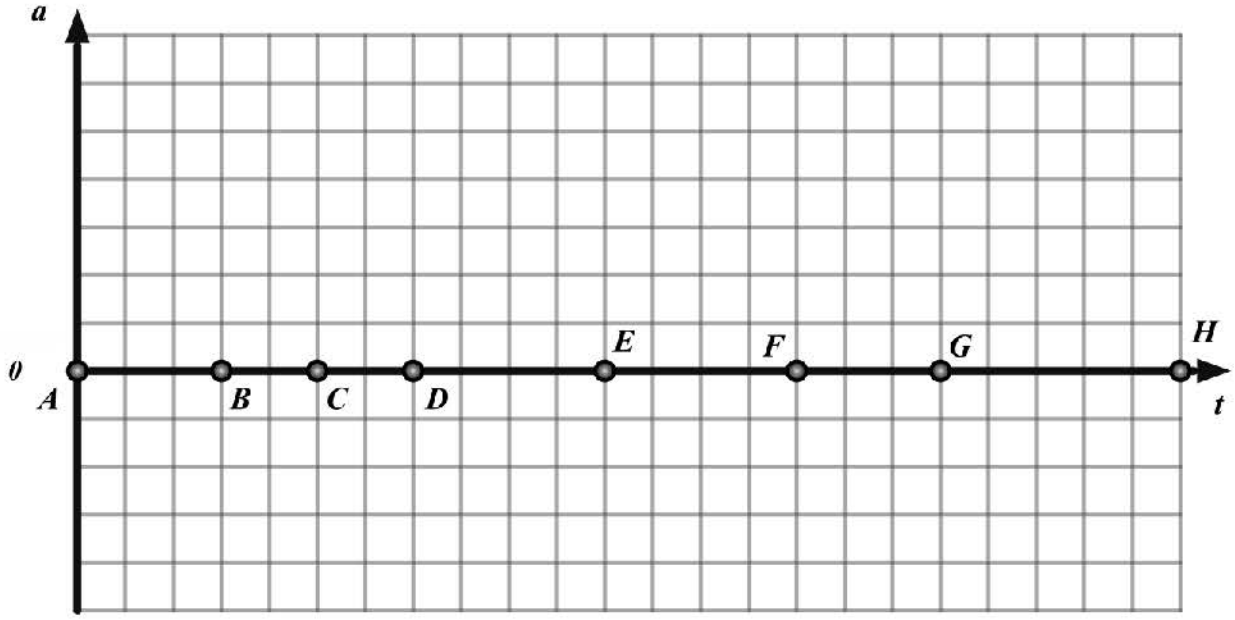
40. Below shows the map of an MTR in Island line and a *v-t* graph of the train.





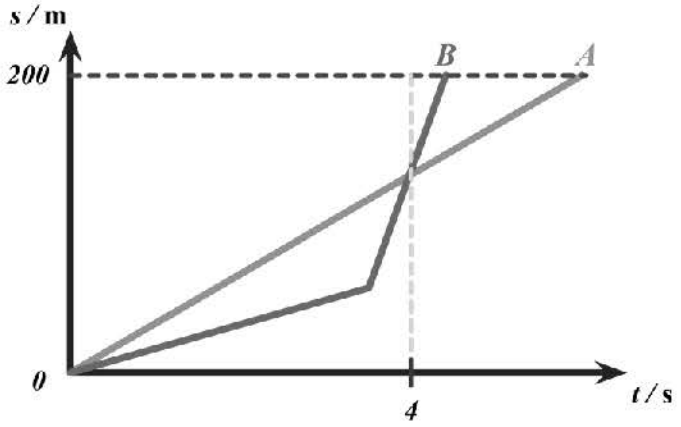
(a) Describe the train's motion.

(b) Draw the a-t graph.



Examples that you must fully understand

41. Two cars A and B in a race of 200 m, straight road move in different way as shown in the displacement-time graphs. Which of the following is / are correct?



(1) Car A wins the race.

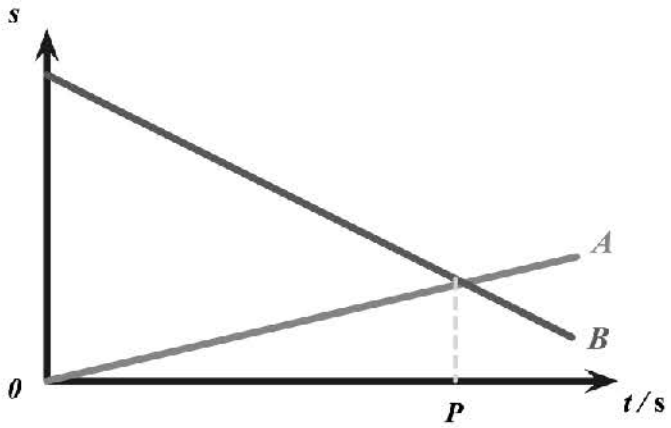
(2) Car B is overtaking car A at t = 4 s.

(3) The average velocity in the first 4 seconds of car A is higher than that of car B.

(4) Car A has eventually travelled a longer distance.

(5) Average velocity of the whole journey of car A is lower than that of car B.

42. Two cars A and B travel along a straight road. Their time variations of the displacement from a road sign X are shown in the figure. Which of the following is / are correct?



(1) The velocity of A is increasing while that of B is decreasing.

(2) The two cars always travel towards each other.

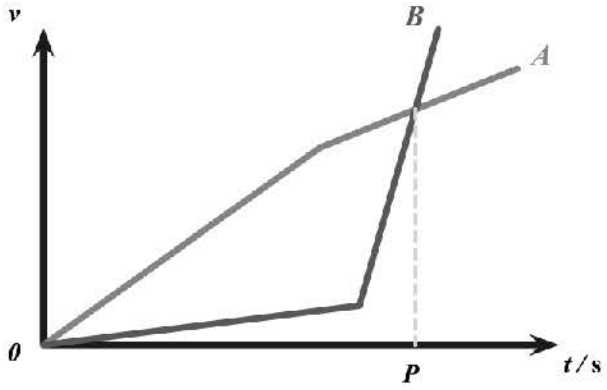
(3) At t = P, the two cars meet each other.

(4) Car A has a greater speed than that of car B.

(5) The area under the graph represents the total distance traveled.

Examples that you must fully understand

43. Two cars A and B travel along a straight road. Their time variations of the velocity are shown in the figure. Which of the following is / are correct?



(1) They meet at t = P.

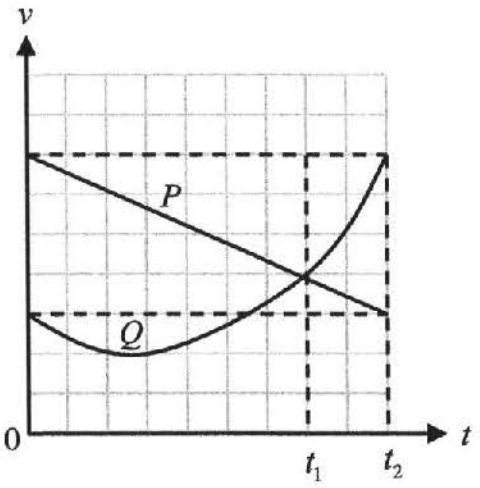
(2) B overtakes A at t = P.

(3) They have the same average velocity during the time interval from 0 to P.

(4) They have the same average acceleration during the time interval from 0 to P.

(5) They have the same displacement during the time interval from 0 to P.

44. The figure shows the velocity-time (v-t) graph of two cars P and Q travelling along the same straight road. At $t = 0$, the cars are at the same position. Which deductions about the cars between $t = 0$ and $t = t_2$ are correct?



(1) P and Q are always travelling in the same direction.

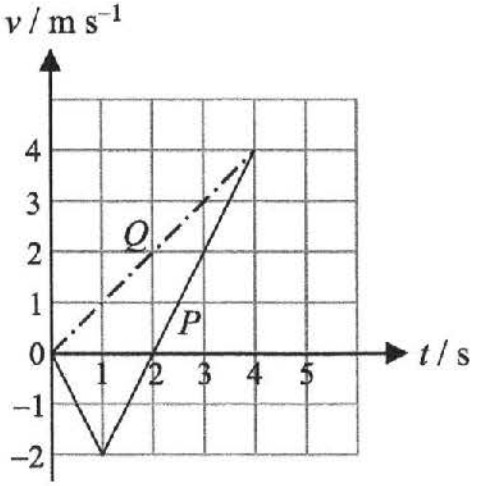
(2) At t = t_1, the separation between P and Q is at a maximum.

(3) At t = t_2, Q lags behind P.

(4) The average velocity of P is greater than that of Q.

(5) Both of the cars are under acceleration during the whole journey.

45. Two particles P and Q start from the same position and travel along the same straight line. The above figure shows the velocity-time (v - t) graph for P and Q. Which of the following descriptions about their motion is / are correct?



(1) At t = 1 s, P changes its direction of motion.

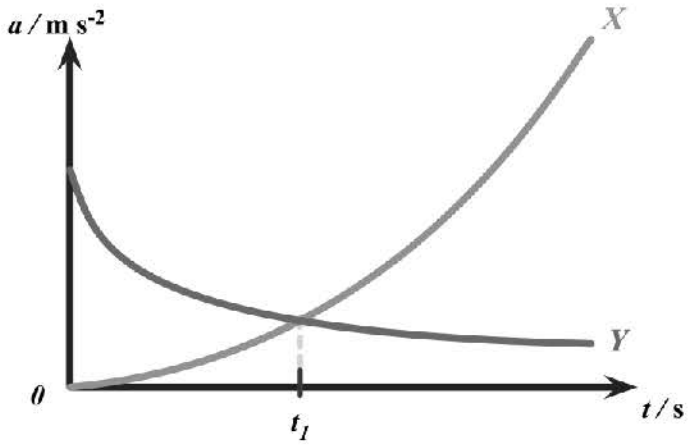
(2) At t = 2 s, the separation between P and Q is 4 m.

(3) At t = 4 s, P and Q meet each other.

(4) At t = 2 s, Q is 2 m in front of P.

Examples that you must fully understand

46. The figure shows acceleration-time graphs of two cars X and Y. X are Y travel along the same straight road. The two curves intersect at $t = t_1$. Which of the following statements concerning the motion of the two cars at time t_1 is always correct?



(1) The two cars meet.

(2) The two cars move at the same speed.

(3) Car X is accelerating and car Y is decelerating.

(4) Both cars are having the same acceleration.

47. State whether each of the following statements is correct or not.

(1) When an object has no acceleration, it must be at rest.

(2) When an object has an acceleration, it must not be at rest.

(3) When an object has an acceleration, it's speed must change.

(4) The direction of velocity and acceleration must be the same.

(5) An object having uniform velocity must travel in a straight line.

48. Which of the following statements about the motion of any two objects is correct?

(1) The object that takes a shorter time to complete the same path must have greater average speed.

(2) The object that travels a greater distance in 1 s must have greater average velocity.

(3) The object with greater velocity must have greater acceleration.

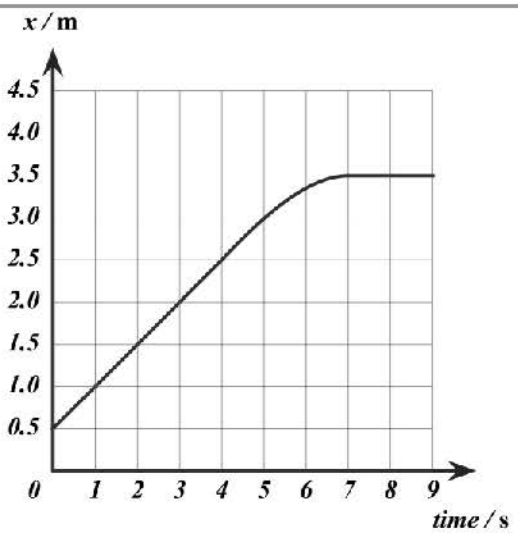
(4) If the two objects have the same acceleration, they must be moving in the same direction.

(5) After completing a journey, the distance travelled by an object must be greater than its displacement.

(6) After completing a journey, the average velocity of an object must be smaller than the average speed.

Examples that you must fully understand

49. Below shows the displacement-time graph of a toy car.



(a) Describe the motion of the toy car.

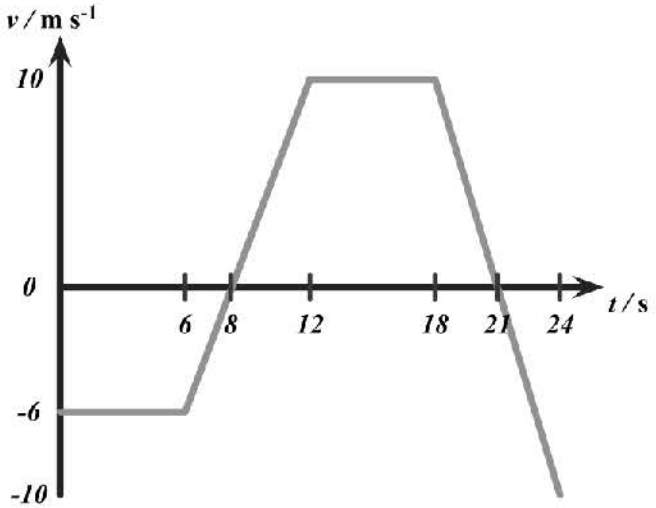
From t = 0 s to t = 4 s, the toy car moves with [ ].

From t = 4 s to t = 7 s, the toy car moves with a [ ].

From t = 7 s to t = 9 s, the toy car is [ ].

(b) Find the average velocity of the toy car from t = 0 to t = 9 s.

50. The given graph shows the motion of an object in 24 s.



(a) Describe the motion of the object.

From t = 0 to 6 s, the object moves [ ] with [ ].

From t = 6 to 8 s, the object moves [ ] with [ ].

From t = 8 to 12 s, the object moves [ ] with [ ].

From t = 12 to 18 s, the object moves [ ] with [ ].

From t = 18 to 21 s, the object moves [ ] with [ ].

From t = 21 to 24 s, the object moves [ ] with [ ].

(b) What is the average speed of the object in these 24 s?

(c) What is the average velocity of the object in these 24 s?

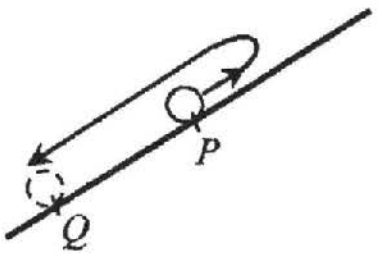
(d) Find the farthest point that the object can reach in the whole journey.

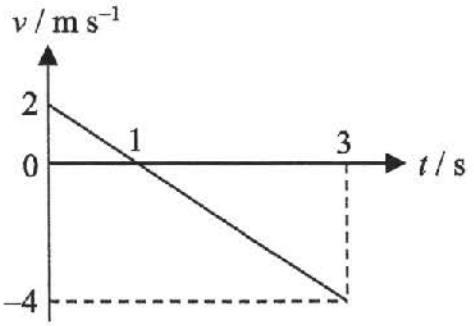
(e) Find the acceleration of the object at t = 8 s and during t = 18 to 21 s.

(f) What is the average acceleration of the object in these 24 s?

(g) If the object keeps moving with the same velocity after t = 24 s, when will the object return back to the starting point?

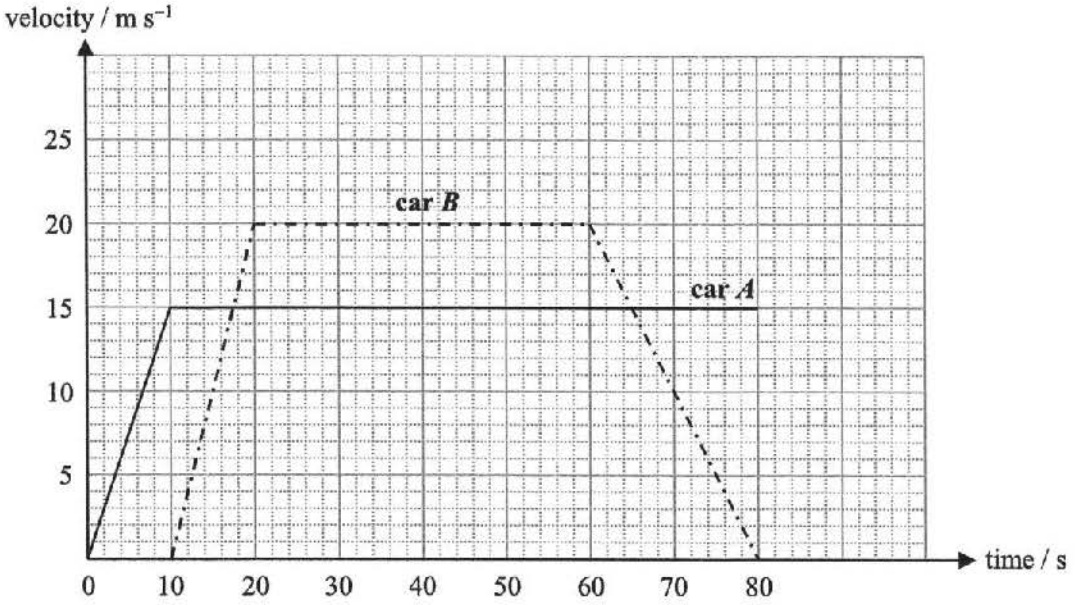
51. A bead is projected up along a smooth incline at point P at time $t = 0$. After reaching the highest point, the bead then travels downwards and passed point Q at $t = 3$ s as shown. The velocity-time (v-t) relationship of the bead is shown in the graph. Find the separation PQ along the incline.



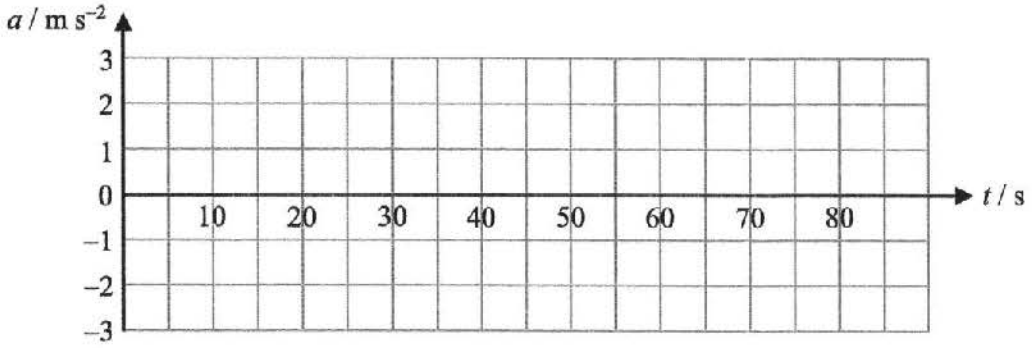


Examples that you must fully understand

52. Two cars A and B initially at the same position, start to travel shows how their velocities vary with time.



(a) Sketch the acceleration-time (a-t) graph of car B from t = 0 to t = 80 s.

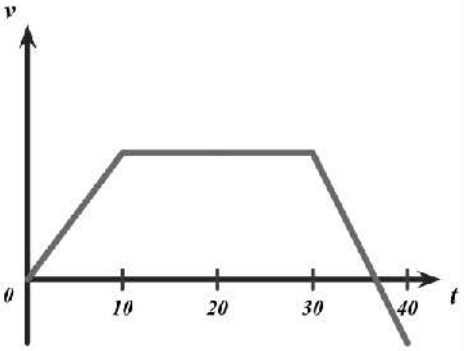


(b) Calculate the maximum separation between cars A and B?

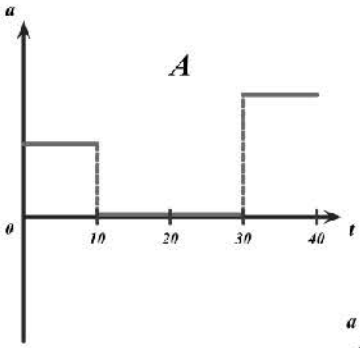
(c) Deduce the time at which car B catches up with car A.

Examples that you must fully understand

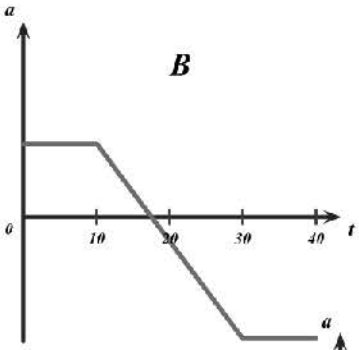
53. The velocity-time graph of a car travelling along a straight horizontal road is shown. Which of the following graphs shows the variation of the acceleration a of the car with time *t*?



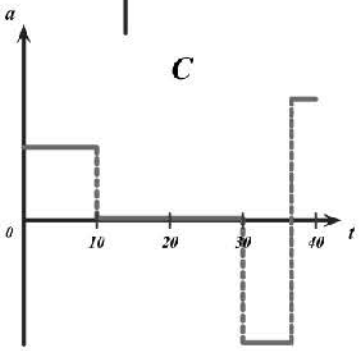
A



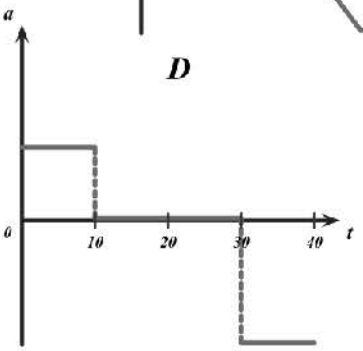
B



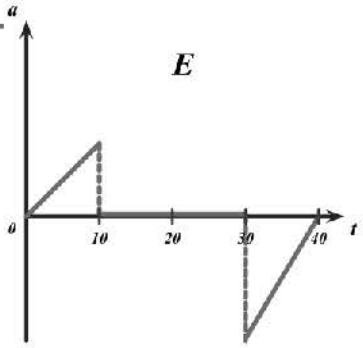
C



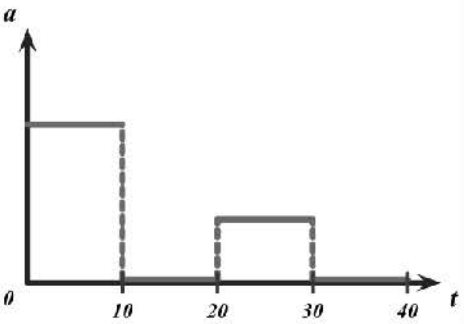
D



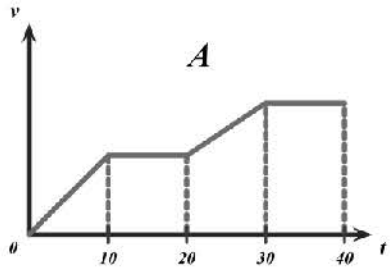
E



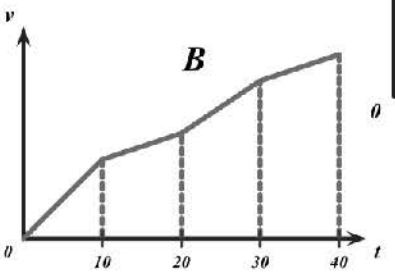
54. A car starts from rest and travels along a straight road. The acceleration-time graph of the car is shown below. Which of the following graphs shows the variation of the velocity *v* of the car with time *t*?



A



B



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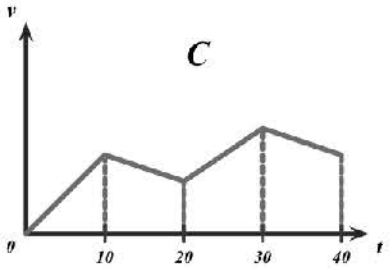

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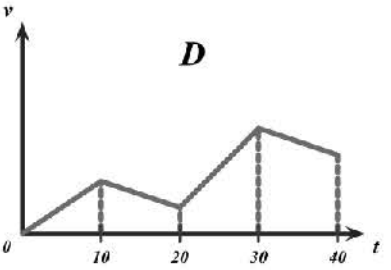
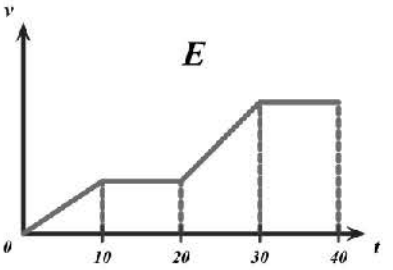
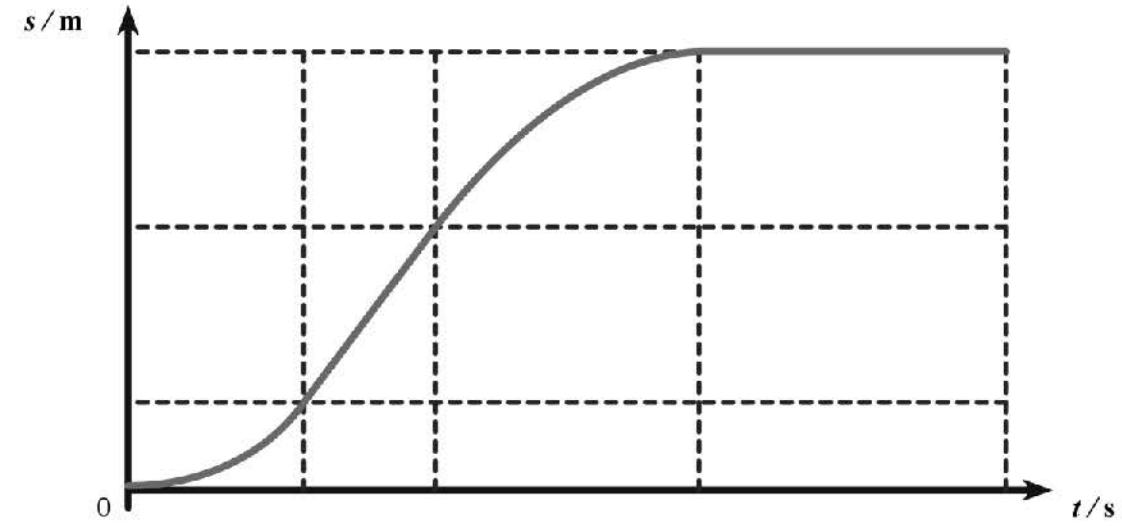


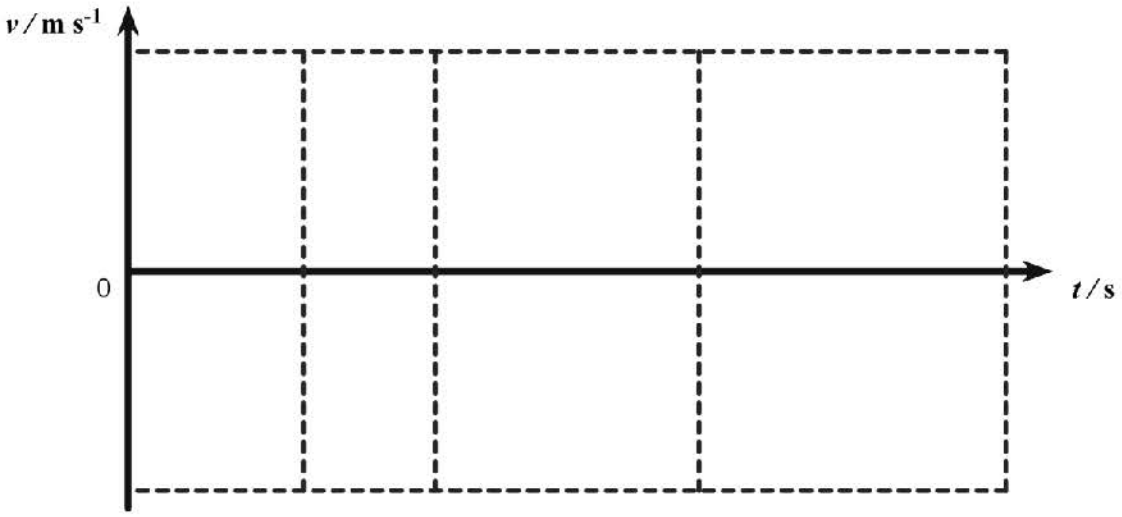
E

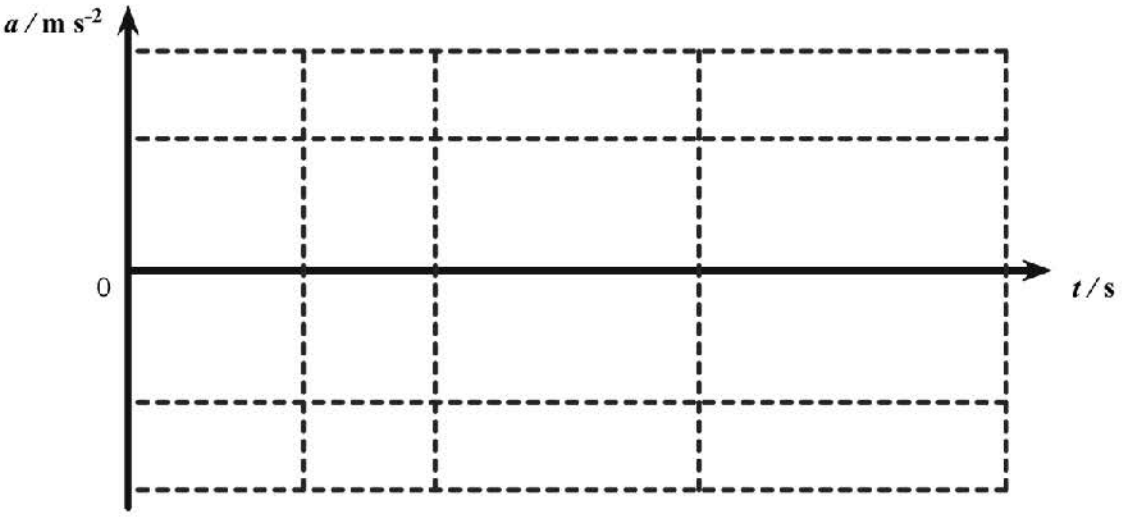


Examples that you must fully understand

55. An object moves along a straight line. Its variation of displacement with time is shown below. Sketch the corresponding velocity-time graph and the acceleration-time graph.







Examples that you must fully understand

56. An object moves along a straight line. Its variation of velocity with time is shown below. Sketch the corresponding displacement-time graph and the acceleration-time graph.