# Chapter 4

## Section 4.1

### 1. Kinematic Equations – Constant Force

Construct a physical situation involving 1-D horizontal motion of a point mass with a constant acceleration that is consistent with the following kinematic equations:

Case A:

$$625 \text{ m} = \tfrac{1}{2} (500\text{N} / 10 \text{ kg}) (5 \text{ sec})^2$$

Case B:

$$2600 \text{ m} = 50 \text{ m} + 5 \text{ m/s} (10 \text{ s}) + \tfrac{1}{2} (500\text{N} / 10 \text{ kg}) (10 \text{ sec})^2$$

Case C:

$$(20 \text{ m/s})^2 = 2 (1000 \text{ N} / 100 \text{ kg}) (20 \text{ m})$$

## 2. Kinematic Equations – Constant Force

State the kinematic equation that would be used if given the following information:

Case A:

M, $F_{net}$, ⊗X, ⊗t, $v_o$

Case B:

M, $F_{net}$, ⊗X, $v_o$, $v_f$

Case C:

M, $F_{net}$, $v_o$, $v_f$, ⊗t

## Section 4.2

### Problems 3 to 5: Motion Diagrams

For each of the motions below sketch a motion diagram as described in section 4.2. You may use a dot to represent the object in motion. First, establish a coordinate axis for each motion. Draw arrows to scale above each dot to represent the velocity vector. Indicate the acceleration direction for each constant-acceleration segment of the motion. (SC)

3. A car is travelling at a constant speed of 35 mph when the driver sees a stop sign. The driver takes 5 seconds to start applying brakes and the car eventually comes to a stop at the stop sign.

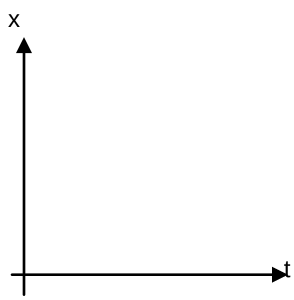
4. In the 100-m dash, a runner begins from rest and accelerates at constant rate until the 60-m mark and then maintains her maximum speed until crossing the finish line.

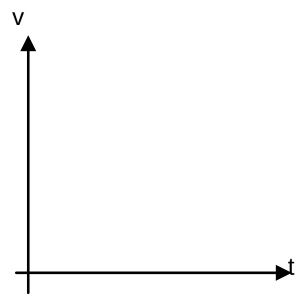
5. You get into an elevator at the ground floor of a 50 story building and press the button for the $50^{th}$ floor. The elevator accelerates for 10 seconds, maintains the maximum speed for 60 seconds and then comes to a stop at the top floor.

### Problems 6 & 7: Graphical Representations of Motion

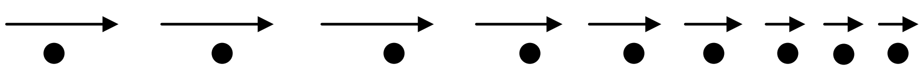
Draw position-vs-time and Velocity-vs-time graphs for the motions represented by the following motion diagrams.

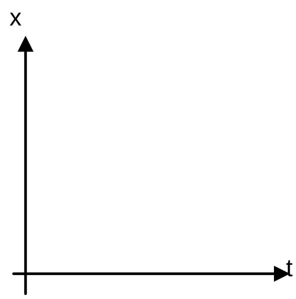
6. 

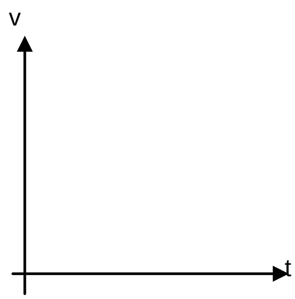



7.





## 8. Graphical Representations of Motion

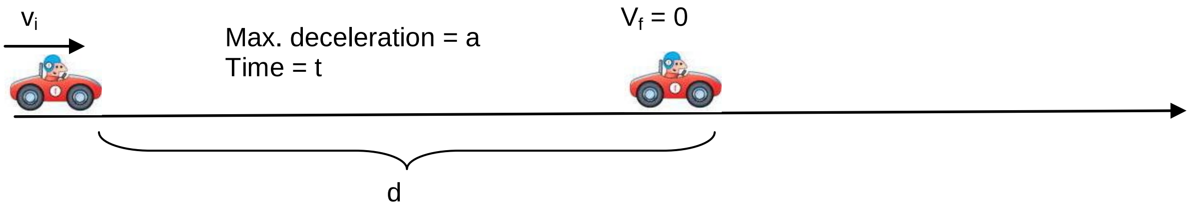
You get on to an elevator on the $50^{th}$ floor and press the button for the ground floor. The elevator speeds up until it reaches the maximum speed, and then maintains this speed for most of the decent. Finally it slows down and stop on the ground floor.

a. Draw the motion diagram for the elevator.

b. Draw velocity-vs-time graph and position-vs-time graph for the elevator.

**9. Kinematics**

A car travelling at a constant speed of $v_i$ can come to a stop in a minimum distance *d* in time t, given that the car has a maximum deceleration *a* when brakes are fully engaged.



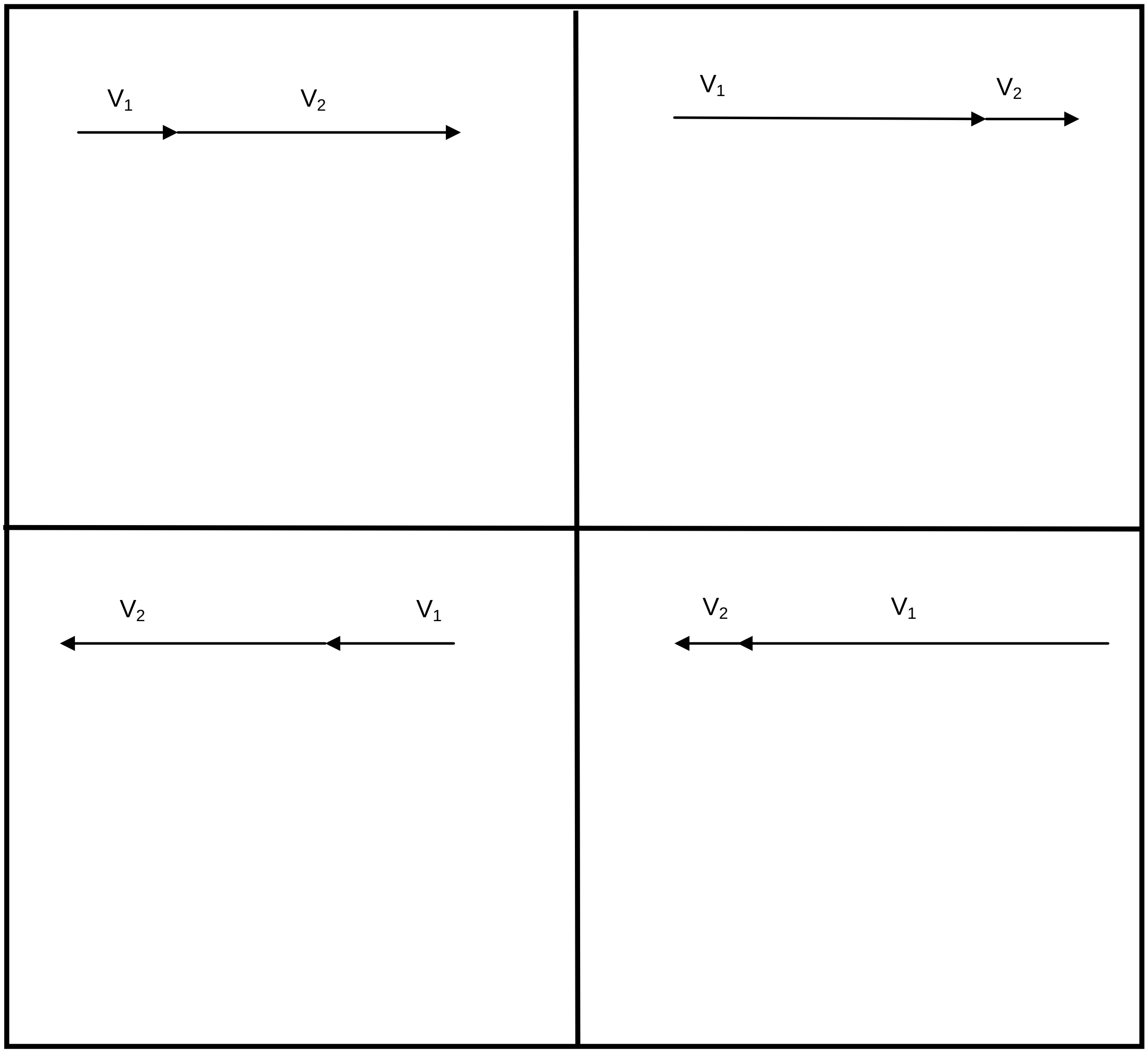

Now suppose the same car (with the same maximum deceleration *a*) is traveling at an initial speed of $2v_i$, and has a minimum stopping distance *d'* in time *t'*. Using kinematic equations, find

a. The ratio $\frac{t'}{t}$

b. The ratio $\frac{d'}{d}$

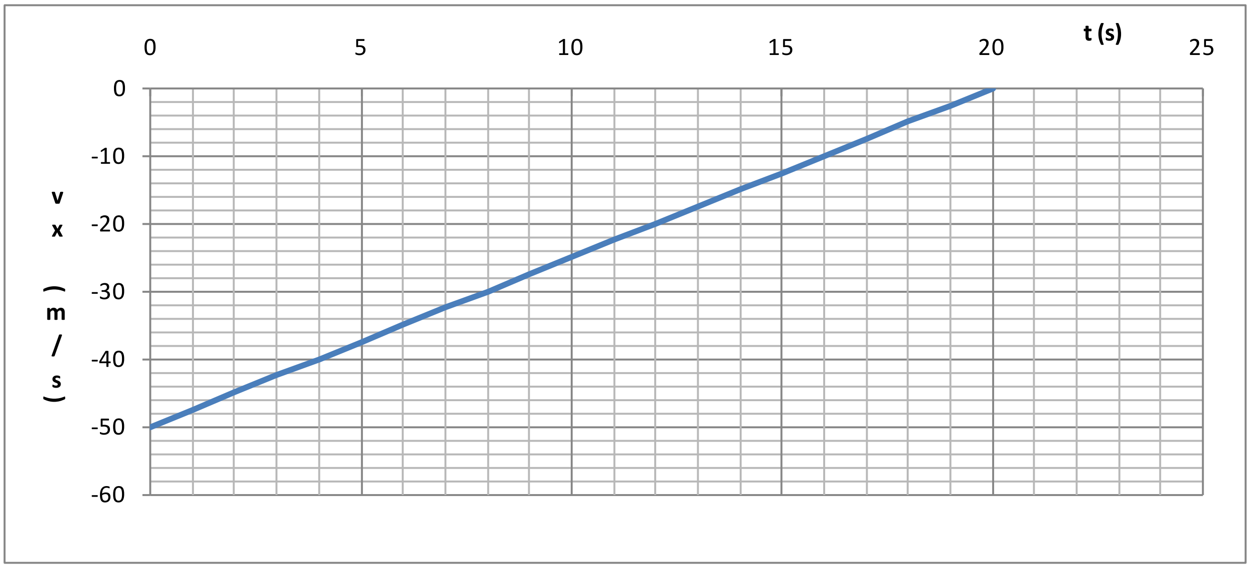
10. **Acceleration Vectors - Graphical**

For each of the partial motion diagrams shown below use the tip-to-tailmethod to graphically determine the direction of the acceleration.



**Problems 11 to 13 : Representations of Motion . [each SC]**

A train of mass $2 \times 10^5$ kg is moving on a straight track, braking to slow down as it approaches a station. The *x*-axis points south. The graph below shows the velocity $v_x$ as a function of time.




**11.** (a) Is the velocity north or south? Explain.

(b) Draw velocity vectors for the train at t = 0, 5 s, and 10 s.

**12**. (a) Is the acceleration constant? Explain.

(b) Find the magnitude of the acceleration. Is the acceleration north or south? Explain.

(c) What is the net force acting on the train?

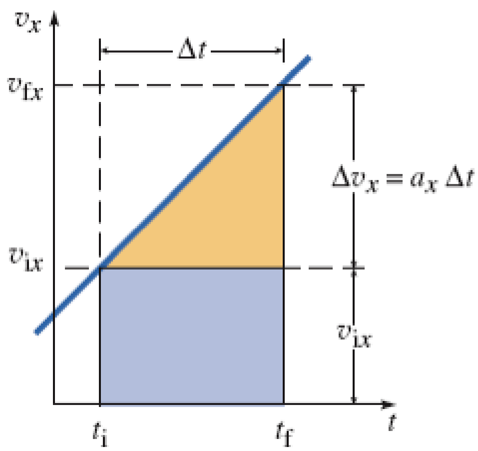
**13**. (a) Is the displacement between t = 5 s and t = 10 s north or south? Explain.

(b) Show on the graph how you would calculate the displacement of the train between t = 5 s and t = 10 s. (No need to calculate the value; just represent the quantity visually.)

(c) Make a qualitative motion diagram for the train (i.e. a series of dots showing the train's position every 5 s). It's not necessary to calculate numerical values; just illustrate qualitatively what the motion is like.

## 14. Graphical Representations of Motion

The graph below shows $v_x(t)$ for an airplane that is speeding up.




(a) Is the acceleration constant? Explain.

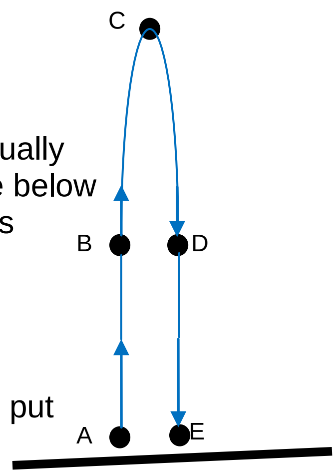
(b) Write an expression for the area of the shaded triangle above $v_{ix}$ in terms of quantities specified on the graph.

(c) Write an expression for the area of the shaded rectangle above $v_{ix}$ in terms of quantities specified on the graph.

(d) Write an expression for the sum of the areas of the triangle and rectangle. What quantity does the total area represent?

Section 4.3: Free-Fall. (Ignore air drag)

15. A ball is thrown vertically up with an initial speed of 30 m/s, and eventually the ball is caught at the same height it was released from. . The figure below shows the vertical position of the ball (A thru E) at 5 different instances during its motion.




a) Ranks these positions according to the acceleration of the ball, from greatest to least acceleration. Place the letter of the position in the appropriate box. If more than one position has the same acceleration, put them in the same box.

| | | | | |
|---|---|---|---|---|
| | | | | |
| Greatest | | | | Least |

Explain your reasoning:

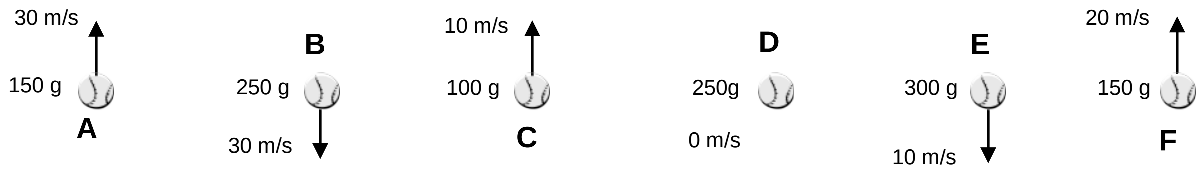
b) Ranks these positions according to the speed of the ball, from greatest to least speed. Place the letter of the position in the appropriate box. If more than one position has the same speed, put them in the same box.

| | | | | |
|---|---|---|---|---|
| | | | | |
| Greatest | | | | Least |

Explain your reasoning:

**Free-Fall**

16. Six balls are simultaneously launched from the same height, but with different speeds and directions. The balls have different masses. The velocities and masses of the six balls are given in each figure.




a) Rank the balls according to their acceleration, soon after being released by the hand.

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Greatest Least

Explain your reasoning:

b) Rank the balls according to the time of flight of each ball (i.e. the time taken from the moment a balls is released to just before hitting the ground)

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Greatest Least

Explain your reasoning:

c) Rank the balls according to the speed of the ball just before hitting the ground

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

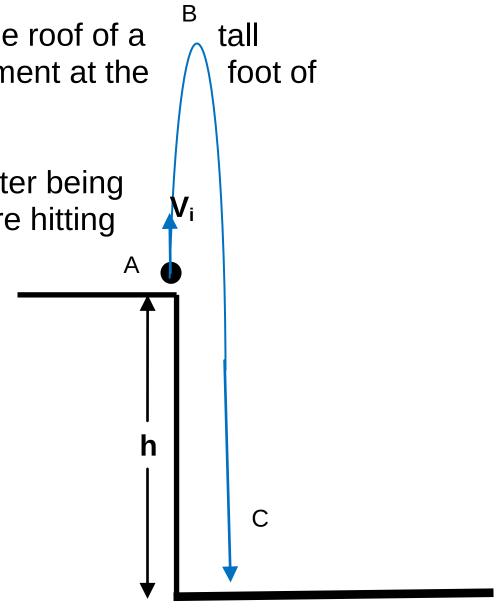
Greatest Least

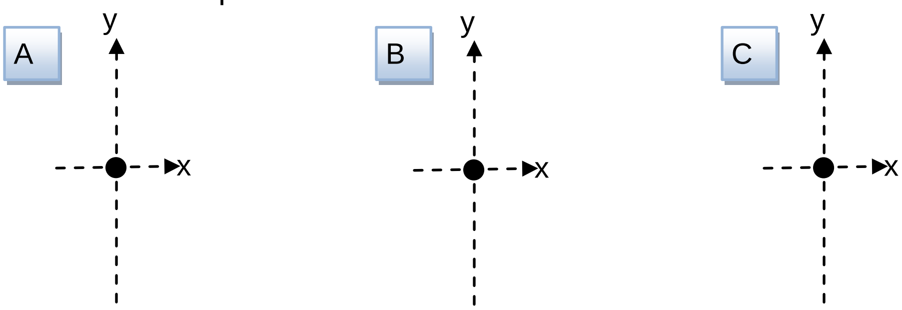
Explain your reasoning:

## 17. Free-Fall

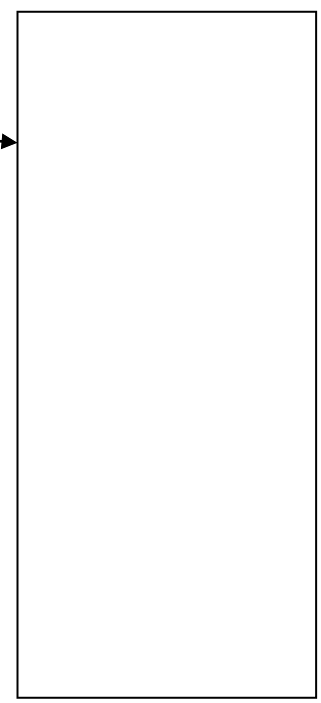
A boy throws a stone straight-up in the air with a speed $v_i$ from the roof of a tall building, as shown below. The stone will eventually hit the pavement at the foot of the building.

a. Draw free-body diagrams for the stone at points A (just after being released by the boy), B (at top of flight) , and C (just before hitting pavement). Then, using Newton's 2nd law, find $\vec{a}$ at each point.

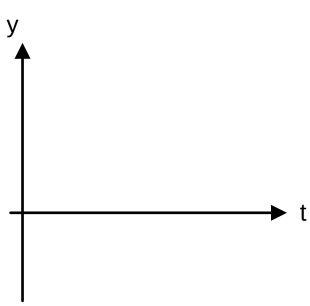


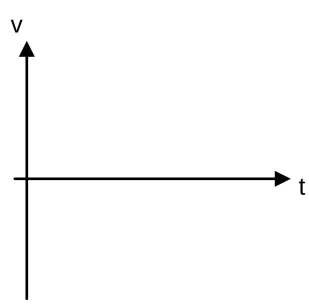




b. Draw the motion diagram of the stone.



c. draw position-vs.-time and velocity-vs.-time graphs for the ball.



## 18. Kinematics

You get into an elevator and push the button for a lower floor. The elevator speeds up, moves at constant speed for a while, then slows to a stop. The y-axis points up.

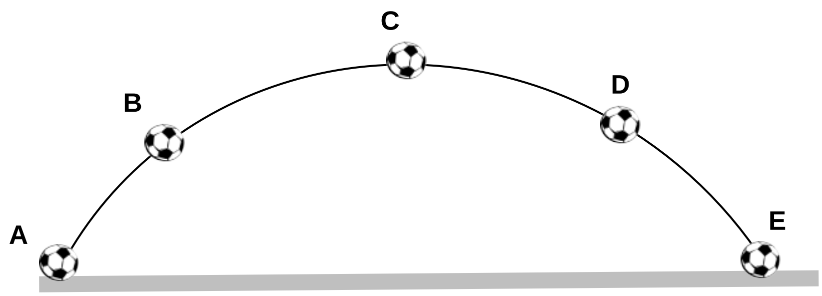
(a) Is the magnitude of the net force on the elevator greater than, equal to, or less than the elevator's weight when it is speeding up, moving at constant speed, and slowing down?

(b) If the only forces acting on the elevator are gravity and a cable pulling upward, is the tension in the cable greater than, equal to, or less than the elevator's weight when it is speeding up, moving at constant speed, and slowing down?

Section 4.4: Projectile Motion (Ignore air drag)

**Problems 19&20: Projectile Motion**

The figure below shows the trajectory of the soccer ball during a goal kick by Tim Howard, the US soccer goalie during a 2010 FIFA world cup game. Six different locations (A – E) of the ball during its motion are also shown in the diagram




19. Rank these six positions according the acceleration of the ball, from greatest to least acceleration. Place the letter of the position in the appropriate box. If more than one baseball has the same acceleration, put them in the same box.

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Greatest Least

Explain:

20. Rank these six positions according the speed of the ball, from greatest to least speed. Place the letter of the position in the appropriate box. If more than one baseball has the same speed, put them in the same box.

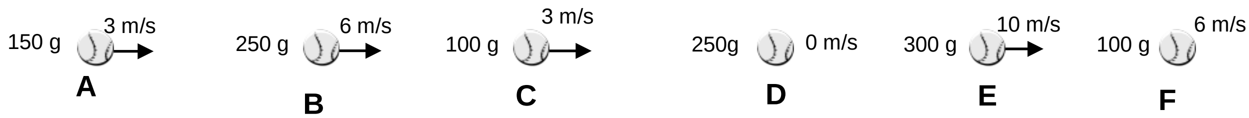
| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Greatest Least

Explain:

**Problems 21 & 22: Projectile Motion**

Consider the motion of six baseballs that have been thrown horizontally from the same height *h* above the ground. Balls have different masses and are thrown with different horizontal speeds as shown in the six diagrams below.

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21. Ranks the baseballs according to how long they take to reach the ground, from greatest to least time. Place the letter of the baseball in the appropriate box. If more than one baseball has the same time of flight, put them in the same box.

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Greatest Least

Explain:

22. Ranks the baseballs according to the speed with which they hit the ground, from greatest to least speed. Place the letter of the baseball in the appropriate box. If more than one baseball has the same speed, put them in the same box

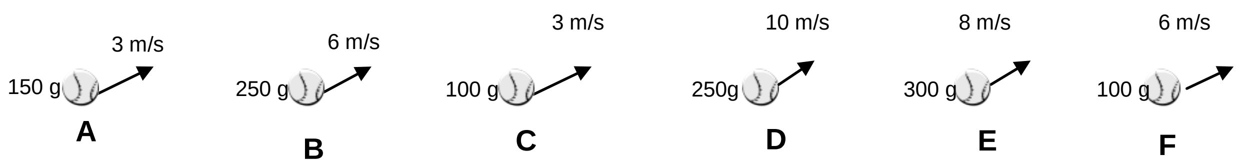
| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Greatest Least

Explain:

**Problems 23 & 24: Projectile Motion**

Consider the motion of six baseballs that have been thrown at an angle from the same height *h* above the ground. The baseballs are thrown at the same angle. However, the Balls have different masses and are thrown with different speeds as shown in the six diagrams below.




23. Rank the baseballs according the maximum height reached by the balls. Place the letter of the baseball in the appropriate box. If more than one baseball has the same max. height, put them in the same box.

Greatest Least

Explain:

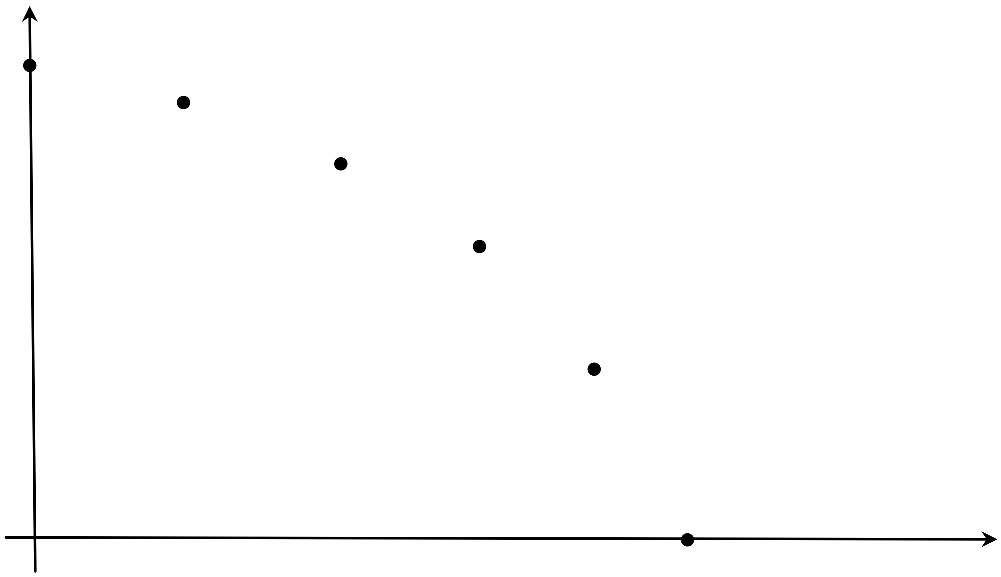
24. Rank the baseballs according to how long they take to reach the ground, from greatest to least time. Place the letter of the baseball in the appropriate box. If more than one baseball has the same time of flight, put them in the same box.

Greatest Least

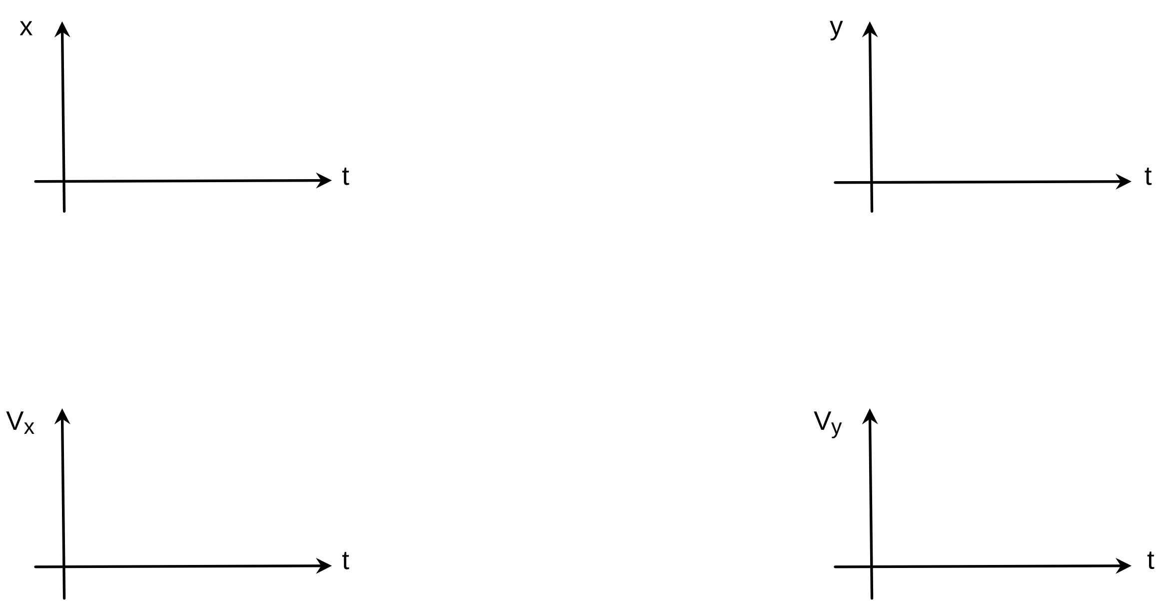
Explain:

**25. Graphing Projectile Motion**

A 2-D motion diagram for an object in projectile motion is shown below.

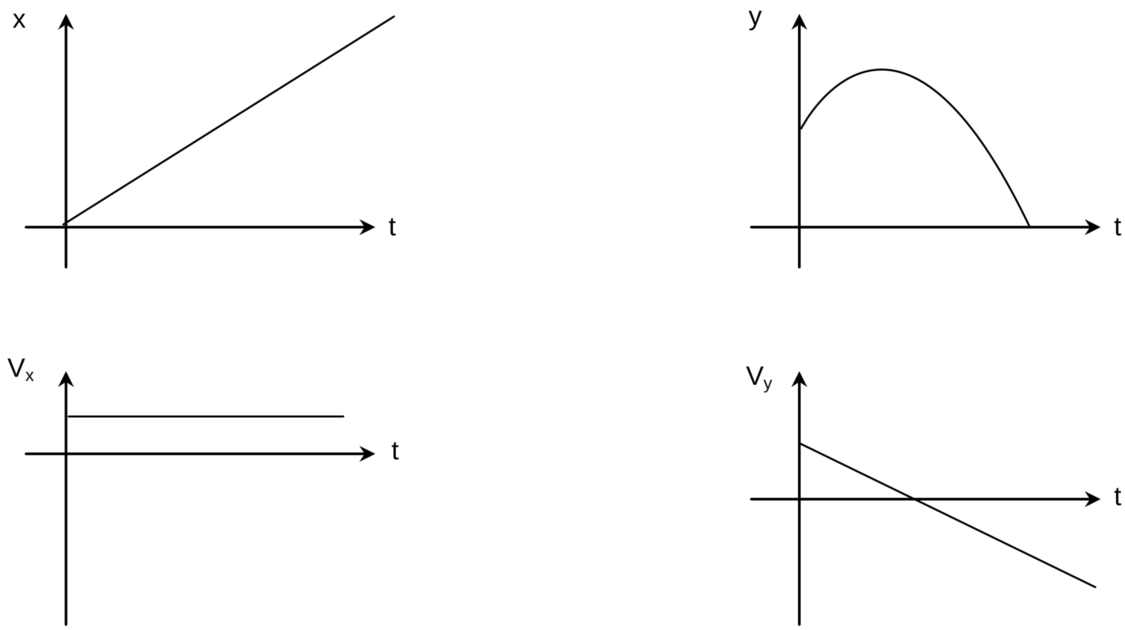


Sketch the corresponding x vs t, y vs t, $v_x$ vs t, and $v_y$ vs t on the axis below.



**26. Graphing Projectile Motion**

Motion graphs for an object in projectile motion are shown below.




a) Construct the corresponding 2-D motion diagram.

b) What is the physical significance of the time when $v_y = 0$?

c) What ia a distinguishing feature of the y vs t graph at this time?

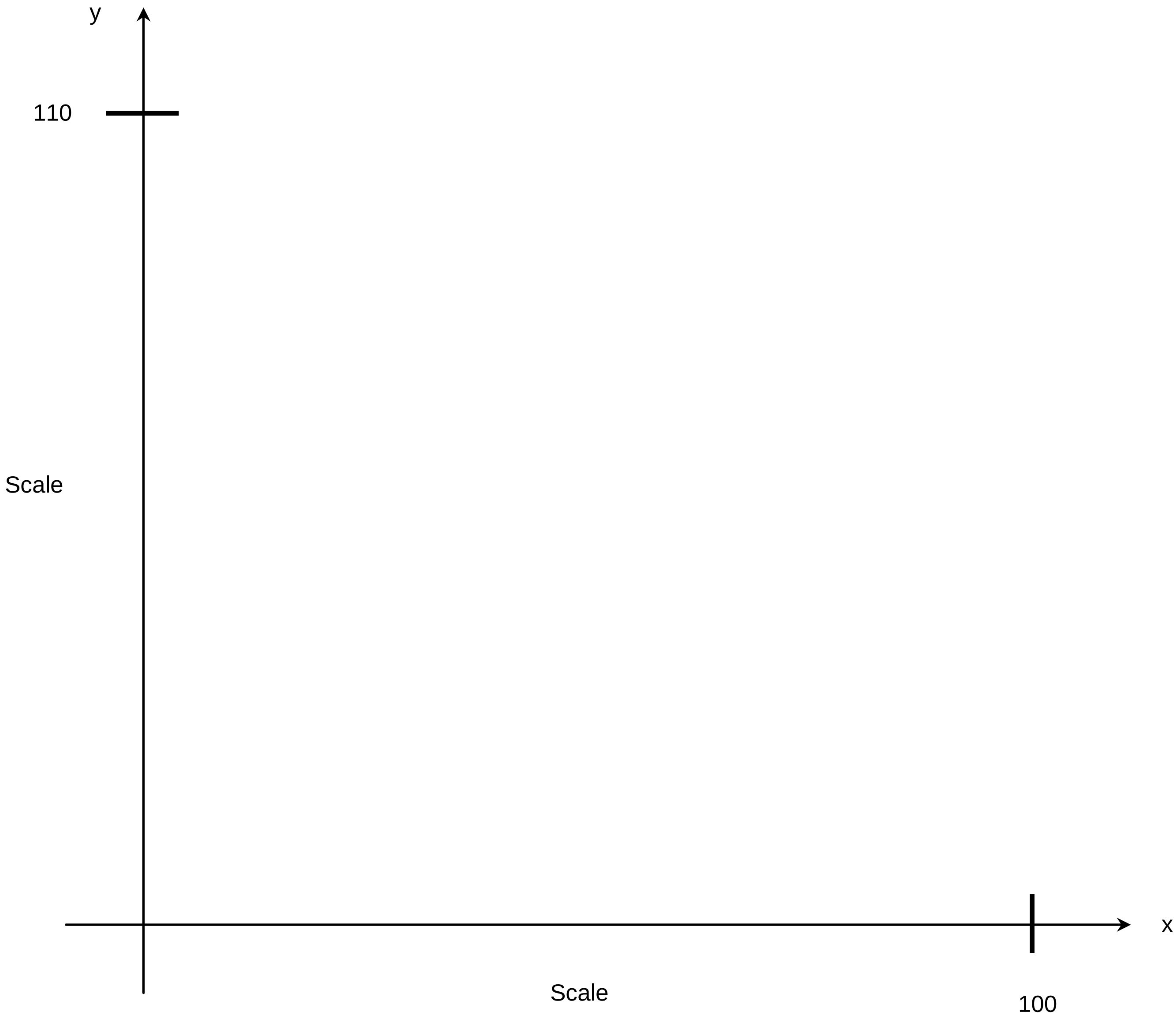
## 27. Trajectory of a Projectile

Construct the 2-D motion diagram for the following initial condions using a time interval of 1 s.

$V_{ox}$ = 10 m/s
$V_{oy}$ = 10 m/s
$X_o$ = 0 m
$Y_o$ = 100 m
g = 10 m/s$^2$, down

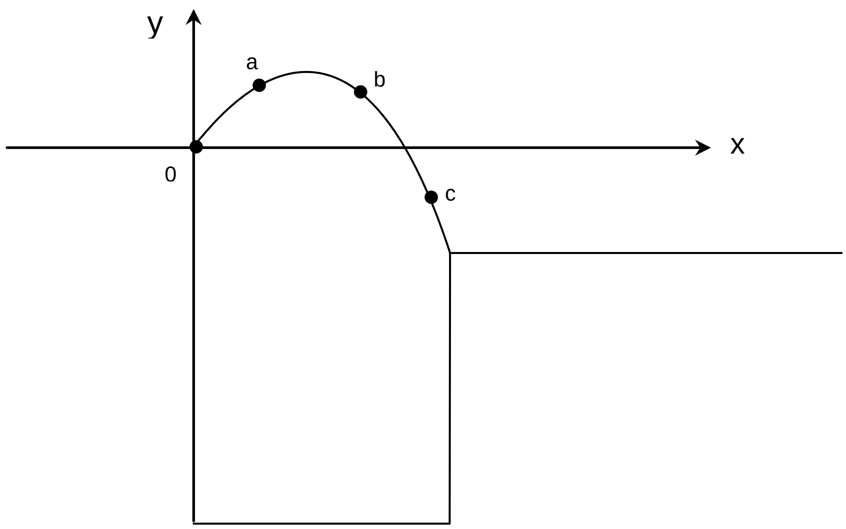
give 3 kinematic eq.

| T (s) | X (m) | Y (m) |
|---|---|---|
| 0 | 0 | 100 |
| 1 | 10 | 105 |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |


y
110
Scale
x
Scale
100

**28. Projectile Motion Coordinate Systems**

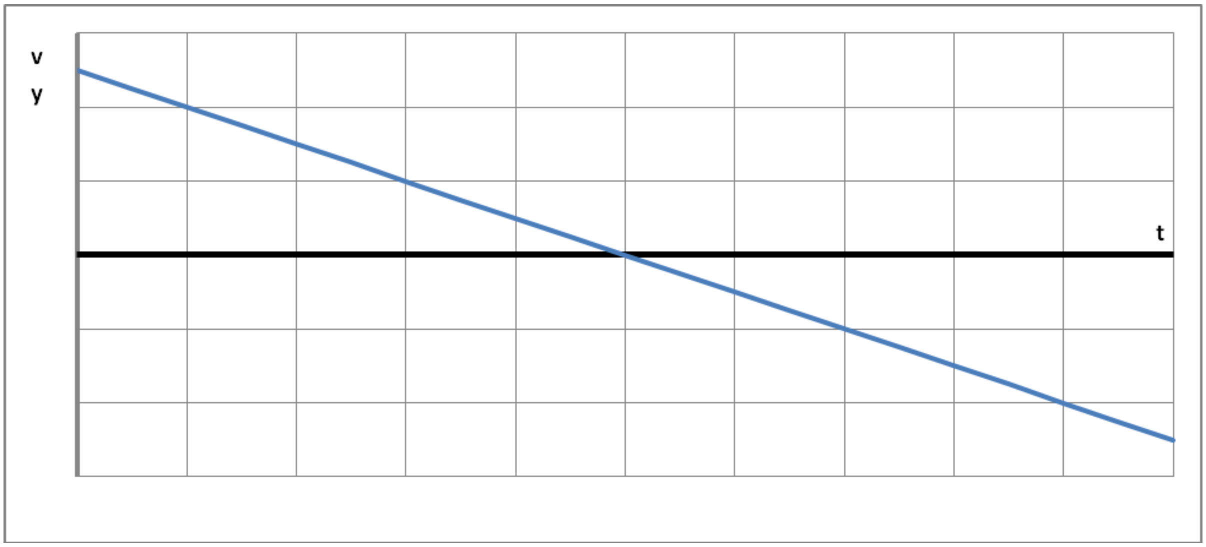
Complete the following chart specifying the sign of the quantity for the lettered points shown on the motion diagram.




| Point | X | $V_x$ | Y | $v_y$ |
|---|---|---|---|---|
| A | | | | |
| B | | | | |
| C | | | | |

**29. Projectile Motion**

The graph shows $v_y(t)$ for a stone thrown straight upward. The y-axis points up.




(a) Mark on the graph the point where the stone is at the top of its trajectory.

(b) At the top of the trajectory, is the acceleration upward, downward, or zero? Explain how the graph supports your answer.

(c) At the top of the trajectory, is the net force on the stone upward, downward, or zero?

## 30 . Projectile Motion

A soccer ball is thrown by the goalie. It follows a parabolic trajectory (air drag is negligible).

(a) Sketch the trajectory of the ball from when it is thrown until it hits the ground.

(b) On your sketch, make a qualitative motion diagram for the stone (i.e. a series of dots showing the stone's position at equal time intervals). Put dot "D" at the highest point in the trajectory and three dots on each side, labeled A-C before the highest point and E-G after it.

(c) At each dot, sketch the components of velocity vector of the ball, showing their directions and their relative magnitudes.