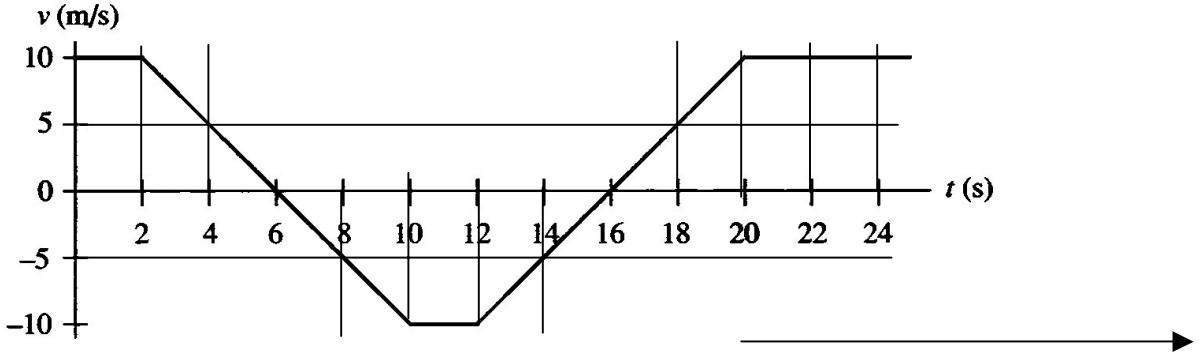
## **Problem 4** (10 points)

The graph below is velocity verses time graph for a particle having an initial position $x_0 = x\ (t = 0) = 0$. At what time or times is the particle located at x = 35 m? Work directly from the graph, using the graphical relationship between velocity and position, and not from any kinematics formulas.




*Each box represents an area = 5 m/s * 2 s = 10 m => each box represents a displacement of 10 m*
*At t = 0 the particle is at x = 0 m*

| *Time interval* | *# of boxes* | *Displacement* | *Position at the end of the time interval (**x = 35 m)* |
|---|---|---|---|
| *0 s to 2 s* | *2 boxes* | *2 boxes * 10 m/box = 20 m* | *x = 20 m* |
| *2 s to 4 s* | *1.5 boxes* | *1.5 boxes * 10 m/box = 15 m* | *x = 20 m + 15 m = 35 m ** |
| *4 s to 6 s* | *0.5 boxes* | *0.5 boxes * 10 m/box = 5 m* | *x = 35 m + 5 m = 40 m* |
| *6 s to 8 s* | *- 0.5 boxes* | *- 0.5 boxes * 10 m/box = -5 m* | *x = 40 m + (-5 m) = 35 m ** |
| *8 s to 10 s* | *- 1.5 boxes* | *- 1.5 boxes * 10 m/box = -15 m* | *x = 35 m + (-15 m) = 20 m* |
| *10 s to 12 s* | *-2 boxes* | *- 2 boxes * 10 m/box = -20 m* | *x = 20 m + (-20 m) = 0 m* |
| *12 s to 14 s* | *-1.5 boxes* | *-1.5 boxes * 10 m/box = -15 m* | *x = 0 m + (-15 m) = -15 m* |
| *14 s to 16 s* | *- 0.5 boxes* | *- 0.5 boxes * 10 m/box = -5 m* | *x = -15 m + (-5 m) = -20 m* |
| *16 s to 18 s* | *0.5 boxes* | *0.5 boxes * 10 m/box = 5 m* | *x = -20 m + 5 m = -15 m* |
| *18 s to 20 s* | *1.5 boxes* | *1.5 boxes * 10 m/box = 15 m* | *x = -15 m + 15 m = 0 m* |
| *20 s to 22 s* | *2 boxes* | *2 boxes * 10 m/box = 20 m* | *x = 0 m + 20 m = 20 m* |
| *22 s to 24 s* | *2 boxes* | *2 boxes * 10 m/box = 20 m* | *x = 20 m + 20 m = 40 m* |

*In the last time interval (22s < t < 24s), the particle clearly passes x = 35 m during this interval.*
*Since velocity is constant, position is changing at a constant rate*

*Since x = 35 m represents ¾ of the displacement during this time interval*
*It will happen ¾ of the way through the time interval at t = 23.5 s*

*So x = 35 m at t = 4 s, 8 s, and 23.5 s*