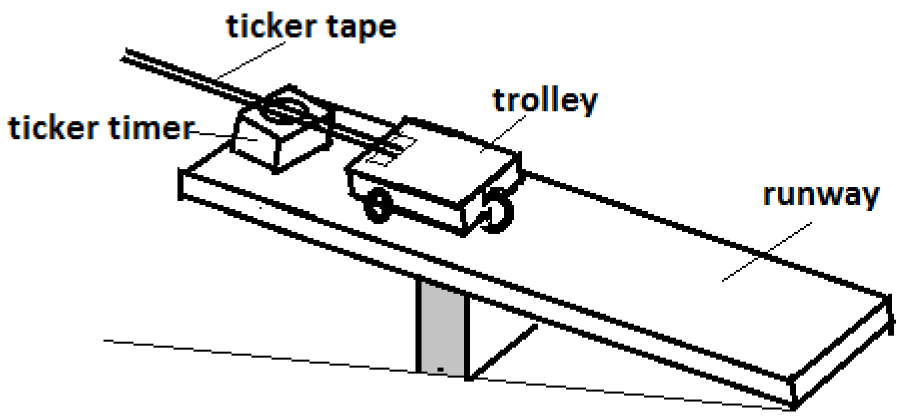
Linear motion part3

Ticker-timer.

The ticker-time is a device that makes dots at a constant rate on a paper tape that is passed through it. The ticker timer is usually connected to electricity that makes it vibrate at a frequency of 50Hz (50 times per second) therefore dots are made on the tape at a rate of 50dots per second.

The dots on the tape can be used to find the velocity or acceleration at which the tape was moving through the ticker-timer.

Using a ticker-timer to find velocity.

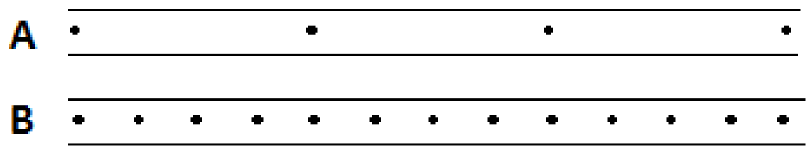


The ticker timer is set up as shown above.

The runway is inclined just enough to make the trolley move along it at constant velocity. This is called friction compensation.

The ticker tape is passed through the ticker timer and then fixed on the trolley. The ticker timer is switched on and the trolley is released to move. The tape with dots on it is cut. Dots at the beginning of the tape are cut off because they are irregular.

Velocity of the trolley is got by making measurements on the space occupied by dots on the tape. The tape may look as shown below.



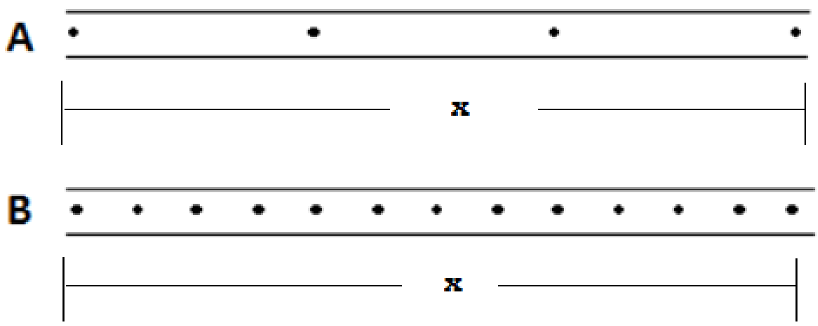
Uniformly spaced dots shows that the trolley was moving at constant velocity.

Tape A shows a trolley that is moving faster that tape B. This is because spacing between the dots of A is bigger than that between the dots of B. The faster the motion, the wider the spacing between dots.

When frequency of the ticker timer is f, the interval between two dots represents time of $T = \frac{1}{f}$seconds.

Therefore when f = 50Hz, then time interval between two dots is, $T = \frac{1}{50}$seconds.

Getting the time



Time is got by counting the number of spaces, **n** on the tape.

Time, $t = \frac{1}{f}\ x\ number\ of\ spaces$.

$t = \frac{1}{f}\ x\ n$

Therefore, $t = \frac{n}{f}$.

For tape A, having 3 spaces the time, $t = \frac{3}{50}$.

For tape B, having 12 spaces the time, $t = \frac{12}{50}$.

Getting distance (displacement)

Displacement is got by measuring the distance, x occupied by the dots on the tape, using a ruler. For example the tapes above have length x = 15cm = 0.15m.

Getting velocity (speed)

Velocity is calculated using the distance, x measure and the time t got.

Velocity, $v = \frac{displacement}{time}$.

$v = \frac{x}{\frac{n}{f}}$.

Therefore, $v = \frac{fx}{n}$.

For tape A, velocity,

$v = \frac{fx}{n}$.

$v = \frac{50 \ x \ 0.15}{3} = 2.5ms^{-1}$.

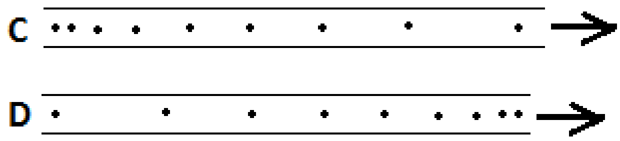
For tape B, velocity,

$v = \frac{fx}{n}$.

$v = \frac{50 \ x \ 0.15}{12} = 0.625ms^{-1}$.

Using a ticker-timer to find acceleration.

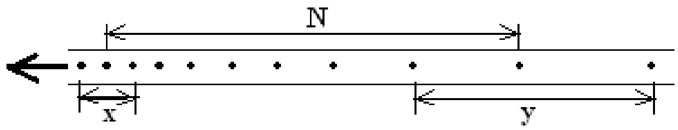
For a tape whose motion is as indicated by the arrows, motion was from left to right. Therefore, the right hand dots are at the beginning and left had dots are at the end.



For tape C the beginning dots are more spaced than the end dots, therefore the tape was slowing down (it was decelerating).

For tape D the beginning dots are less spaced than the end dots, therefore the tape was increasing speed (it was accelerating).

The diagram below shows a tape that moved as indicated by the arrow through the ticker timer of frequency f as indicated. This time dots on the left are the beginning dots.



Therefore initial velocity, u is got by measuring distance x and counting number of space, n on the left.

Initial velocity, $u = \frac{fx}{n}$

Final velocity, v is got by measuring distance y and counting number of space, n on the right of the tape.

Final velocity, $v = \frac{fy}{n}$.

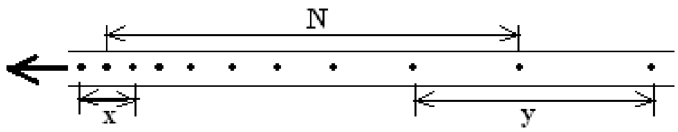
Total time to change from initial velocity, u to final velocity, v is got by counting spaces, N from the middle of x to the middle of y.

Total time, $T = \frac{N}{f}$

Acceleration, $a = \frac{v-u}{T}$.

$a = \frac{\frac{yf}{n} - \frac{xf}{n}}{\frac{N}{f}}$.

$a = (\frac{yf}{n} - \frac{xf}{n})\frac{f}{N}$.



For example, in the diagram above n = 2, N = 8 and f = 50Hz.

In case the measure value of x = 8cm = 0.08m, y = 25cm = 0.25m.

Final velocity, $v = \frac{fy}{n}$.

$v = \frac{50\ x\ 0.25}{2} = 6.25ms^{-1}$.

Initial velocity, $u = \frac{fx}{n}$.

$v = \frac{50\ x\ 0.08}{2} = 2.0ms^{-1}$.

Time, $T = \frac{N}{f}$

$T = \frac{8}{50}$.

Acceleration, $a = \frac{v-u}{T}$.

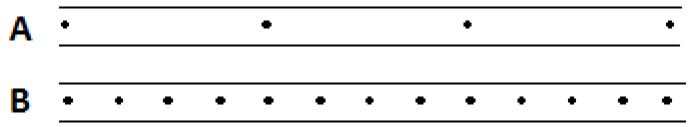
Acceleration, $a = \frac{6.25-2}{\frac{8}{50}}$.

$26.5625ms^{-2}$.

Exercises.

1. (a) Describe how the ticker timer is used to measure constant velocity of a trolley.
   (b) Explain why the runway is inclined.
   (c) Explain why is advisable to cut off and ignore beginning part of the tape.
2. (a) If frequency of the ticker timer is f Hertz, what is the time interval between two dots?
   (b) The frequency of a ticker timer is 40Hz. Find the time interval covered by 10dots on a ticker tape produced by this ticker timer.

3. (a) The tapes below were got using two different trolleys.



Describe the difference in motion of trolleys A and B

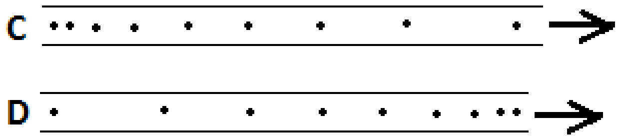
(b) Given that each of the two tapes is 40cm long and frequency of the ticker timer is 50Hz, find:

(i) Velocity of trolley A

(ii) Velocity of trolley B

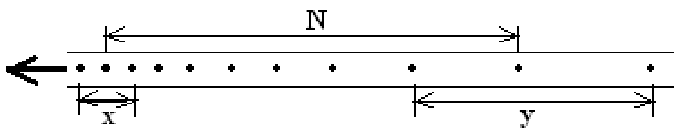
4. (a) Describe how the ticker timer is used to measure acceleration of a trolley.

(b) The ticker tapes below were got using trolleys C and D. The arrow shows direction in which the tape moved through the ticker timer.



Describe the difference in motion of trolleys A and B

5. (a) The diagram below shows a tape that moved as indicated by the arrow through the ticker timer of frequency 40Hz as indicated.



(i) Write the formula for acceleration in terms of N, x and y.

(ii) Find acceleration when x = 8cm and y = 25cm.