Speed analogy in escalators:

In this section, let us discuss in detail about the speed,time analogy of various cases when a person is going up in an escalator.

Case a)When the speed of escalator going up is varying and the speed of man climbing on it is constant:

a_1)When the escalator stops due to power failure for few seconds somewhere between and then resumes its journey while the person is taking steps on it at a uniform speed:

If the total number of steps of the escalator is x , 'a' denotes the number of seconds that it halts due to power failure somewhere in between, 't' is the total time taken in seconds by the escalator to reach x steps and if the escalator runs uninterrupted for a total of t_1 seconds, S_1 and S_2 being the speed in steps/second of the escalator (while running)and the man respectively ,

Total time taken by the man to reach the top $t = t_1 + a$, in seconds…….(1)

Total number of steps of the escalator $x = t_1*(S_1+S_2) + a(0+ S_2)$ (because for those 'a' seconds, escalator is idle)…….(2)

Total number of steps taken by the person in climbing up,$x_2 = t_1*S_2+ a*S_2$…….(3)

Average speed of the escalator $S_{av} =(S_1*t_1)/t$,in steps/second…..(4)

Example: When an escalator moving upwards having 40 steps halts for 4 seconds somewhere between and then resumes its journey while a person moving on it is taking steps at a constant speed such that the ratio of speed of escalator to that of the man is 3:1,

i. What is the total time taken by the man to climb up the escalator if he would require 30 seconds to reach the top by taking 10 steps had it not been for the halt?
ii. What would be the total number of steps he had taken to reach the top?
iii. What is the average speed of the escalator?

Solution:

i. As the man takes 30 seconds to take 10 steps if not for the halt, his speed is (1/3) steps per second. As escalator's speed is thrice his speed, it is equal to 1 step/second.

$((4/3)+(4/3)*t_1) = 40$ (from equation(2))

Hence, t_1= 29 seconds.

Hence total time taken by the man to climb up the escalator = 29+4= 33 seconds. (from equation (1)).

ii. Total number of steps taken by the person in climbing up = (1/3)*33=11 steps(from equation(3))
iii. Average speed of the escalator = (29/33) steps/second (from equation (4))

a_2) When the speed of the escalator varies from S_1 to S_{1NEW} after a specific time whereas the speed of the person climbing up is constant:

In the above case, if t_1 represents time interval of travelling at a speed of S_1 and t_2 ,the time interval of travelling at a speed of S_{1NEW} ,'t' representing the total time taken for the person to climb the escalator,

$$t = t_1 + t_2 \quad \text{.....(5)}$$

Total number of steps of escalator $x = t_1*(S_1+S_2) + t_2*(S_{1NEW}+ S_2)$.....(6)

Total number of steps taken by the person in climbing up,

$$x_2 = t_1*S_2 + t_2*S_2 \quad \text{.....(7)}$$

Average speed of the escalator $S_{av} = ((S_1*t_1)+(S_{1NEW}*t_2))/t$,in steps/second.....(8)

Example: When an escalator moving upwards has a speed of 1 step/second for the first 10 seconds and 1.5 steps/second for the next 15 seconds with the person taking a total of 15 steps to reach the top at a constant speed,

i. What is the individual speed of the man?
ii. What is the average speed of the escalator?

Solution:

i. $15 = 25*S_2$ (from equation (7))
$S_2 = (3/5)$ steps/second.

ii. $S_{av} = ((1*10)+(1.5*15))/25$ (from equation (8))
= 1.3 steps/second.