Physics Homework 1

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Problem 1 (25 pts)
The figure below shows the time dependence of velocity. Do the following:

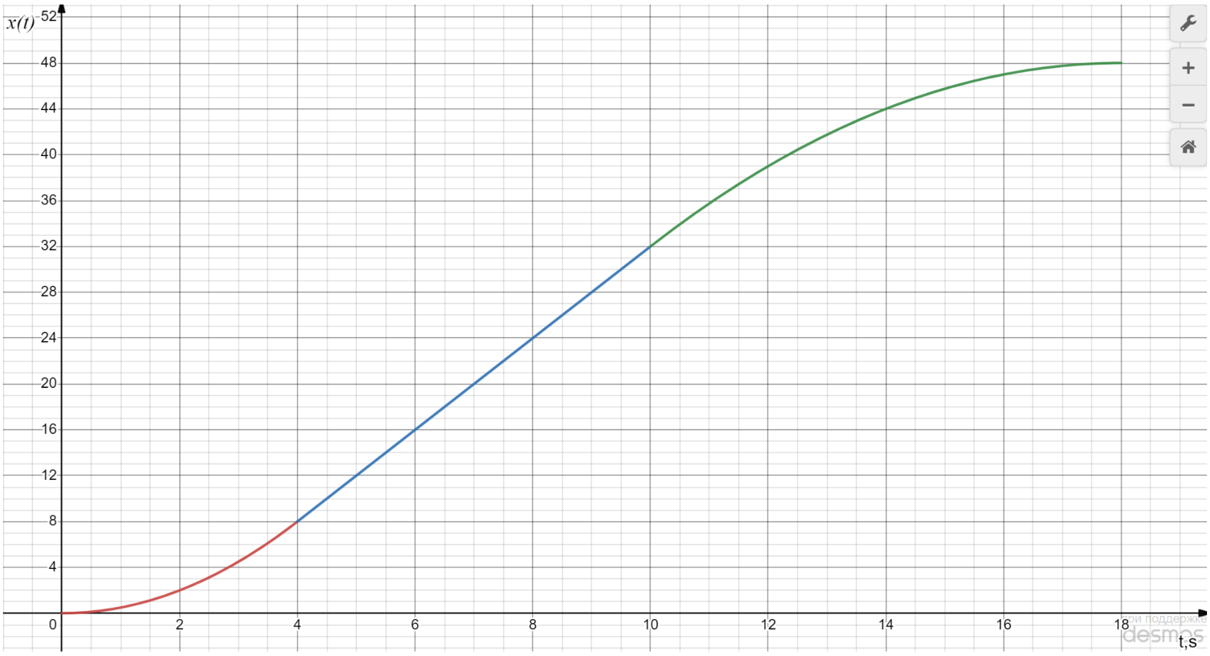
1. Plot the acceleration and displacement with respect to time. Assume, the initial coordinate is x(0) = 0 m.
2. Determine the displacement and the average velocity over time interval [t1, t3].

Given: t1 = 4 s, t2 = 10 s, t3 = 18 s.

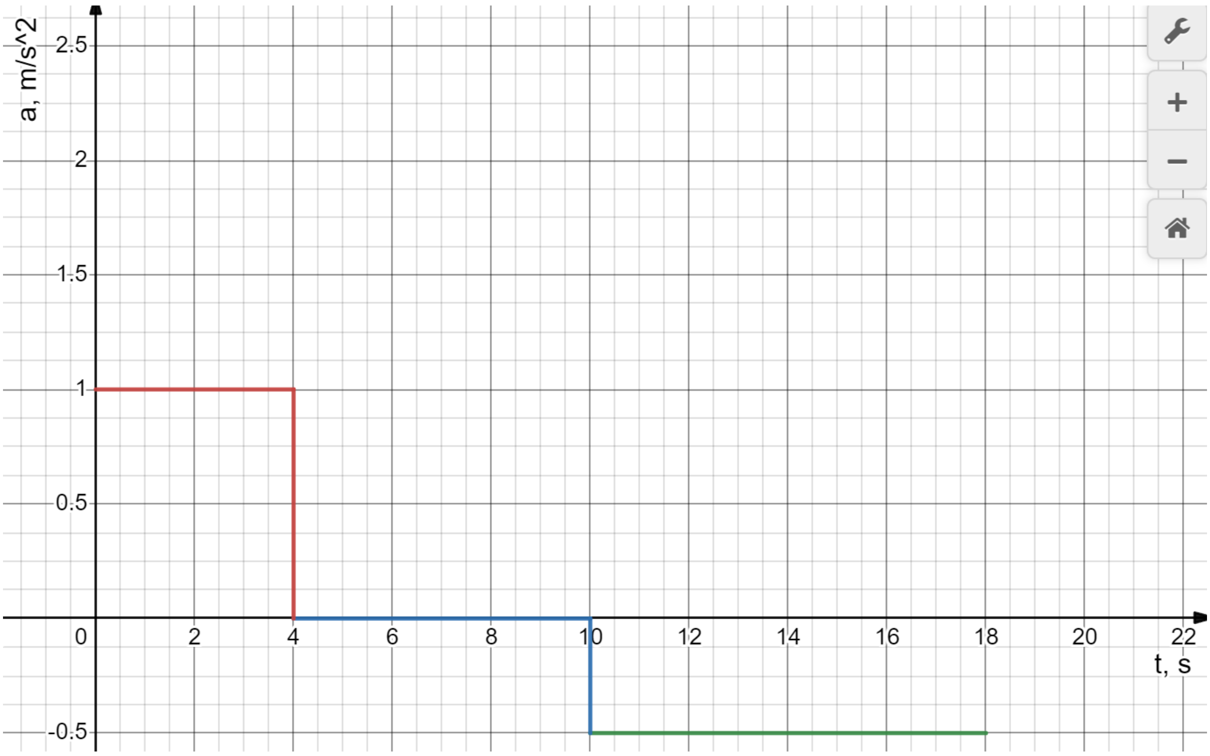
Solution:

1.

Displacement Red(a=1), Blue(a=0), Green(a=-0.5)



Acceleration



2. Let S be displacement on [t1,t3] then it will be equal to S1+S2(Where S1 displacement on t1-t2 and S2 displacement on t2-t3)

$S_1 = V_0 t_{1-2}$= 4*(10-4)=24 m

$S_2 = V_0 t_{2-3} + a t_{2-3}^2/2$=4*(18-10)-(0.5*(18-10)^2/2)=32-16=16 m

S=16+24=40 m

Answer: 40 m

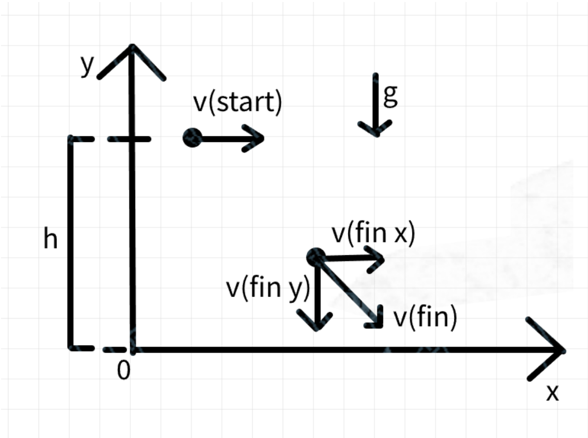
Average velocity will be defined as all displacement divided time period

$V_{aver} = (S_1 + S_2)/(t_{1-2} + t_{2-3}) = 40/14 = 2.86\, m/s$

Problem 2 (25 pts)

A ball is thrown horizontally from a height of 20 m and hits the ground with a speed that is three times its initial speed. What is the initial speed? Assume that there is no air drag and therefore acceleration in the horizontal direction is zero.

Solution:



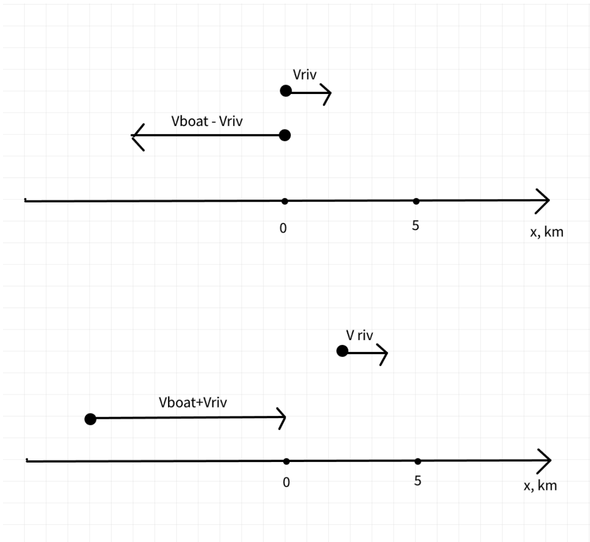
<table>
<tr><td>Given:
g=9.8 m/s^2
h=20 m
$v_{fin} = 3v_{start}$</td><td>In the first moment of time projection of velocity on axis OY is 0 according to the task the ball was thrown horizontally. We obtain case according to projection on OY where $y_{start} = h,\ v_{y(start)} = 0, y_{fin} = 0.$ Write an equation for displacement. Projection g on OY is g.</td></tr>
<tr><td>Find:
v_{start} −?</td><td>$y_{fin} = y_{start} - g^* t^2/2$. According to this we can find time.
t=$\sqrt{(y_{start} - y_{fin}) * 2/g}$
Now we can find $v_{y(fin)} = g *\sqrt{(y_{start} - y_{fin}) * 2/g}$
Let's have a look at the projection at OX.
Start Speed v_{start} will be projected as $v_{x(start)}$ it was thrown horizontally so $v_{start} = v_{x(start)}$. We have only one force which has perpendicular direction to OX so it would not evolve on v_x part of the speed. So it would be the same at the last moment. $v_{x(start)}$=$v_{x(fin)}$
We know that $v_{fin} = 3v_{start};\ v_{fin} = \sqrt{v_{y(fin)}^2 + v_{x(fin)}^2}$
$9v_{start}^2 = v_{y(fin)}^2 + v_{x(fin)}^2$
$8v_{start}^2 = v_{y(fin)}^2$

$8v_{start}^2 = g^2 *(y_{start} - y_{fin}) * 2/g$</td></tr>
</table>

<table>
<tr><td></td><td>$8v_{start}^{2} = g *(y_{start} - y_{fin}) * 2$
$4v_{start}^{2} = g *(y_{start} - y_{fin})$
$v_{start} = \sqrt{g * (y_{start} - y_{fin})/4}$

Count:
$v_{start} = \sqrt{9.8 * 20/4} = 7\ m/s$
Answer: 7m/s</td></tr>
</table>

Problem 3 (25 pts)
The fisherman on the boat moves up the river. Under the bridge, he drops a bottle into the water. Half an hour later, the fisherman turns back, moves down the river and finds the bottle 5 km down the flow from the bridge. What is the speed of the river if the speed of the boat is constant?
Solution:



<table>
<tr><td>Given:
$t_0 = 0.5\ h$
s= 5 km</td><td rowspan="2">So let’s split our task into two parts. First Top of the picture. Second down of the picture. Take the OX axis and bridge as a zero. During 0.5 hour they move away from each other. Removal speed
$v_{rem} = v_{boat} - v_{riv} + v_{riv} = v_{boat}$
$S_{rem} = v_{boat} * t_0$
Picture second: Distance between bottle and boat S_{rem}.
They approach with speed v_{app} $=v_{boat} + v_{riv} - v_{riv} = v_{boat}$
So they will meet after $t_1 = S_{rem}/v_{app} = v_{boat} * t_0/v_{boat} = t_0$
So we obtain equality so they will remove and approach in equal time.
During t_0+t_1 bottle go for s=5 km. Find the velocity of the river.
v_{riv}=s/(t_0+t_1)=s/(2t_0)=5/1=5 km/h
Answer:5 km/h</td></tr>
<tr><td>Find:
v_{riv} −?</td></tr>
</table>

Problem 4 (25 pts)
The maximum speed of an athlete is 14 m/s. After start, he runs with constant acceleration and then keeps maximum speed for the rest of the race. As a result, it takes him 11 s to cover 100 m distance. What is the acceleration of the athlete?

Solution:

Given: $v_{max} = 14\, m/s$ S= 100 m t = 11 s a=const for all period	Firstly he run with acceleration for some time t_0 then he run with constant speed for t_1. Write displacement throw time. Initial speed=0 initial s=0. S=a*$t_0^2/2 + v_{max} * t_1$. Also we know that $t - t_0 = t_1$. Rewrite. S=a*$t_0^2/2 + v_{max} * (t - t_0)$. Go forward. $v_{max} = a * t_0$ $v_{max}/a = t_0$. Rewrite S=a*$(v_{max}/a)^2/2 + v_{max} * (t - (v_{max}/a))$. S=$v_{max}^2/2a+ v_{max} * (t - (v_{max}/a))$.
Find: a-?	S=$v_{max}^2/2a+v_{max} * t - v_{max}^2/a$ aS=$v_{max}^2/2+v_{max} * t * a - v_{max}^2$ a(S-$v_{max} * t) = v_{max}^2/2- v_{max}^2$ a=$(v_{max}^2/2- v_{max}^2$)/(S-$v_{max} * t)$ Count: a=$(14^2/2 - 14^2)/(100 - 14 * 11) = 49/27 = 1.81$ Answer: 1.81

1. Path. Red part with acceleration. Green part without acceleration