Today: 11.2

$\boxed{L2}$

Today: 11.2

$\boxed{L2}$

Special cases & relative motion

Today: 11.2

Tuesday: 11.4

$\boxed{L2}$

Today : 11.2

Tuesday : 11.4

$\boxed{L2}$

Curvilinear motion of particles

Previously:

Previously: $v = \frac{dx}{dt}$

Previously: $v = \frac{dx}{dt}$ & $a = \frac{dv}{dt}$

Previously: $v = \frac{dx}{dt}$ & $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$

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If $a = \text{const.}$

Previously: $v = \frac{dx}{dt}$ & $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$

If $a = \text{const.}$ $\quad \frac{dv}{dt} = a \Rightarrow \int \frac{dv}{dt} dt = a \int dt$

Previously: $v = \frac{dx}{dt}$ & $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$

If $a = \text{const.}$ $\frac{dv}{dt} = a \Rightarrow \int \frac{dv}{dt} dt = a \int dt$

$\Rightarrow \int dv = a \int dt$

Previously: $v = \frac{dx}{dt}$ & $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$

If $a = \text{const.}$ $\quad \frac{dv}{dt} = a \Rightarrow \int \frac{dv}{dt}\,dt = a\int dt$

$\Rightarrow \int dv = a\int dt \Rightarrow v - v_0 = at$

Previously: $V = \frac{dx}{dt}$ & $a = \frac{dV}{dt} = \frac{d^2x}{dt^2}$

If $a = \text{const.}$ $\quad \frac{dV}{dt} = a \Rightarrow \int \frac{dV}{dt}\,dt = a\int dt$

$\Rightarrow \int dV = a\int dt \Rightarrow V - V_0 = at \Rightarrow V = at + V_0$

ASU

Previously: $V = \frac{dx}{dt}$ & $a = \frac{dV}{dt} = \frac{d^2x}{dt^2}$

If $a = \text{const.}$ $\frac{dV}{dt} = a \Rightarrow \int \frac{dV}{dt} dt = a \int dt$

$\Rightarrow \int dV = a \int dt \Rightarrow V - V_0 = at \Rightarrow V = at + V_0$

But $V = \frac{dx}{dt}$

Previously: $V = \frac{dx}{dt}$ & $a = \frac{dV}{dt} = \frac{d^2x}{dt^2}$

If $a = \text{const.}$ $\frac{dV}{dt} = a \Rightarrow \int \frac{dV}{dt} dt = a \int dt$

$\Rightarrow \int dV = a \int dt \Rightarrow V - V_0 = at \Rightarrow V = at + V_0$

But $V = \frac{dx}{dt}$ so $\int \frac{dx}{dt} dt = \int (at + V_0) dt$

Previously: $V = \frac{dx}{dt}$ & $a = \frac{dV}{dt} = \frac{d^2x}{dt^2}$

If $a = \text{const.}$ $\frac{dV}{dt} = a \Rightarrow \int \frac{dV}{dt} dt = a\int dt$

$\Rightarrow \int dV = a\int dt \Rightarrow V - V_0 = at \Rightarrow V = at + V_0$

But $V = \frac{dx}{dt}$ so $\int \frac{dx}{dt} dt = \int (at + V_0) dt$

$\Rightarrow \int dx = \int (at + V_0) dt$

Previously: $V = \frac{dx}{dt}$ & $a = \frac{dV}{dt} = \frac{d^2x}{dt^2}$

If $a = \text{const.}$ $\quad \frac{dV}{dt} = a \Rightarrow \int \frac{dV}{dt} dt = a \int dt$

$\Rightarrow \int dV = a \int dt \Rightarrow V - V_0 = at \Rightarrow V = at + V_0$

But $V = \frac{dx}{dt}$ so $\int \frac{dx}{dt} dt = \int (at + V_0) dt$

$\Rightarrow \int dx = \int (at + V_0) dt \Rightarrow x - x_0 = \frac{1}{2} a t^2 + V_0 t$

Previously: $v = \frac{dx}{dt}$ & $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$

If $a = \text{const.}$ $\quad \frac{dv}{dt} = a \Rightarrow \int \frac{dv}{dt} dt = a \int dt$

$\Rightarrow \int dv = a \int dt \Rightarrow v - v_0 = at \Rightarrow v = at + v_0$

But $v = \frac{dx}{dt}$ so $\quad \int \frac{dx}{dt} dt = \int (at + v_0) dt$

$\Rightarrow \int dx = \int (at + v_0) dt \Rightarrow x - x_0 = \frac{1}{2} a t^2 + v_0 t$

$$\Rightarrow \quad x = \frac{1}{2} a t^2 + v_0 t$$

Previously: $V = \frac{dx}{dt}$ & $a = \frac{dV}{dt} = \frac{d^2x}{dt^2}$

If $\boxed{a = \text{const.}}$ $\frac{dV}{dt} = a \Rightarrow \int \frac{dV}{dt}dt = a\int dt$

$\Rightarrow \int dV = a\int dt \Rightarrow V - V_0 = at \Rightarrow \boxed{V = at + V_0}$

But $V = \frac{dx}{dt}$ so $\int \frac{dx}{dt}dt = \int (at + V_0)dt$

$\Rightarrow \int dx = \int (at + V_0)dt \Rightarrow X - X_0 = \frac{1}{2}at^2 + V_0 t$

$$\Rightarrow \boxed{X = \frac{1}{2}at^2 + V_0 t + X_0}$$

Also $a = \frac{dv}{dt}$ &

Also $a = \frac{dv}{dt}$ & $\frac{dv}{dt} = \left(\frac{dv}{dx}\right)\left(\frac{dx}{dt}\right)$

&

Also $a = \frac{dv}{dt}$ & $\frac{dv}{dt} = \left(\frac{dv}{dx}\right)\left(\frac{dx}{dt}\right)$

& $v = \frac{dx}{dt}$

Also $a = \frac{dv}{dt}$ & $\frac{dv}{dt} = \left(\frac{dv}{dx}\right)\left(\frac{dx}{dt}\right)$

& $v = \frac{dx}{dt} \Rightarrow a = v\frac{dv}{dx}$

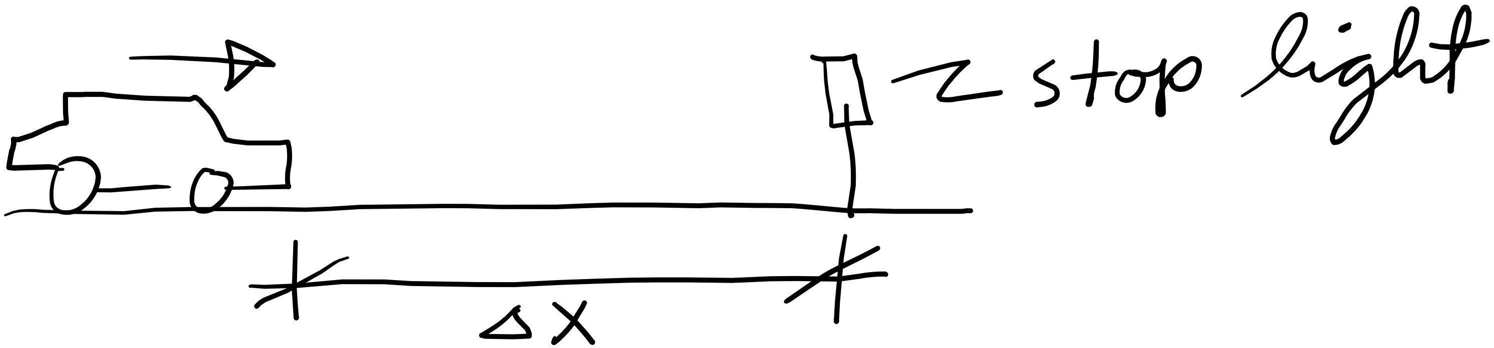
Also $a = \frac{dv}{dt}$ & $\frac{dv}{dt} = \left(\frac{dv}{dx}\right)\left(\frac{dx}{dt}\right)$

& $v = \frac{dx}{dt}$ $\Rightarrow$ $a = v\frac{dv}{dx}$ → Important

form for work/energy relation

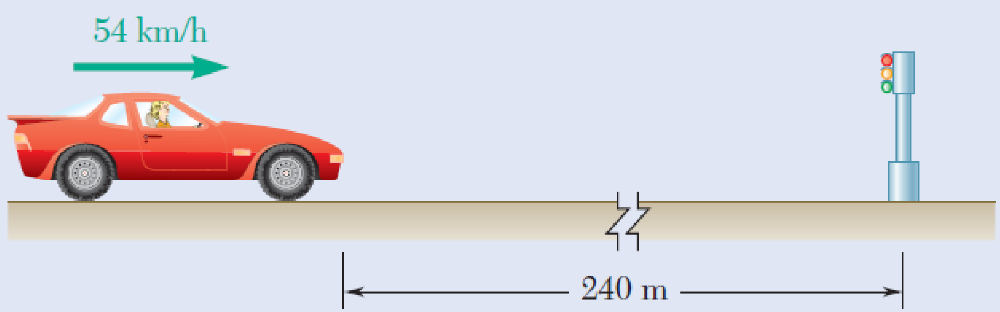
Notes on problems

Notes on problems : $\boxed{11.34}$

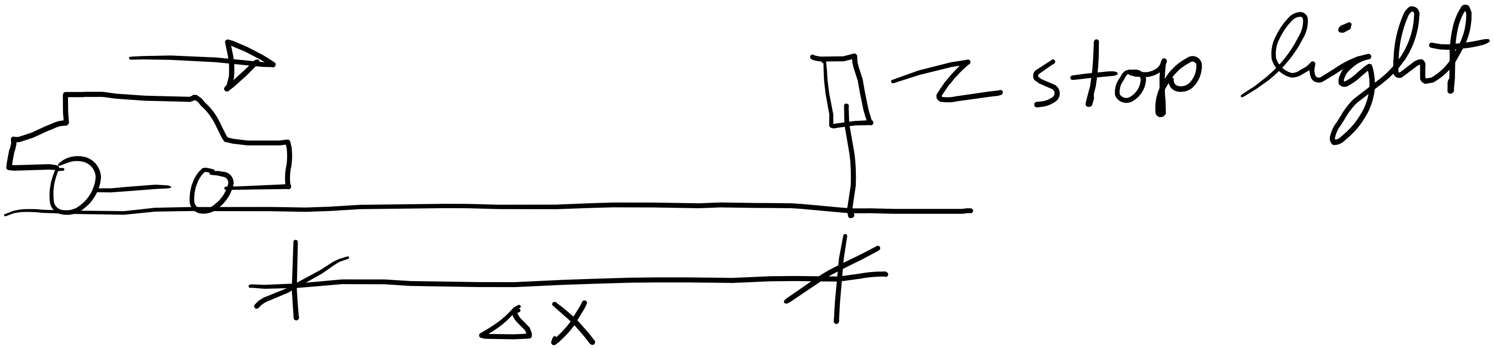


Given: $V_0 = 54\frac{km}{hr}$, $\Delta x = 240m$, $\Delta t = 24s$ & $a = const.$

11.34 A motorist is traveling at 54 km/h when she observes that a traffic light 240 m ahead of her turns red. The traffic light is timed to stay red for 24 s. If the motorist wishes to pass the light without stopping just as it turns green again, determine (*a*) the required uniform deceleration of the car, (*b*) the speed of the car as it passes the light.



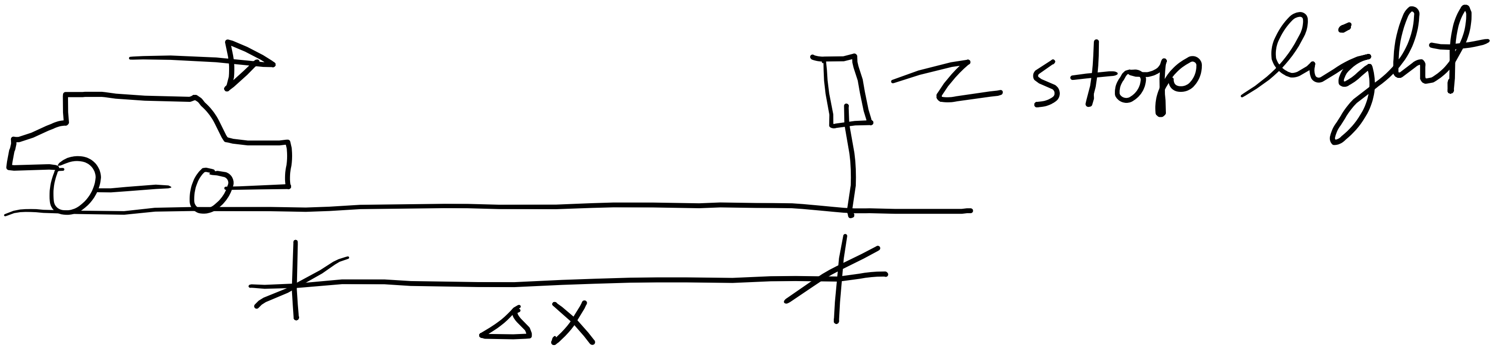
Notes on problems: $\boxed{11.34}$



Given: $V_0 = 54\frac{km}{hr}$, $\Delta x = 240m$, $\Delta t = 24s$ & $a = const.$

Note units!!

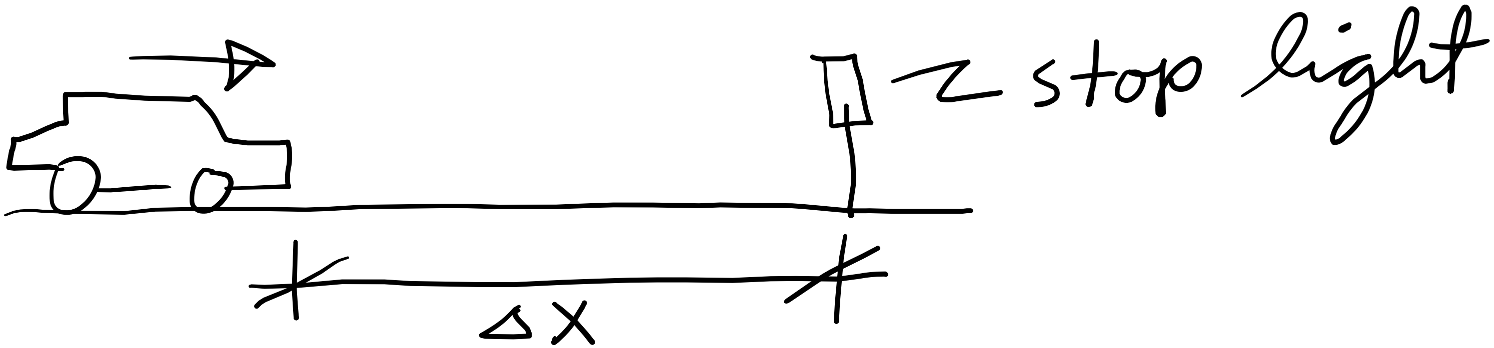
Notes on problems : $\boxed{11.34}$



Given: $V_0 = 54\frac{km}{hr}$, $\Delta x = 240m$, $\Delta t = 24s$ & $a = const.$

(a) Find a:

Notes on problems : $\boxed{11.34}$

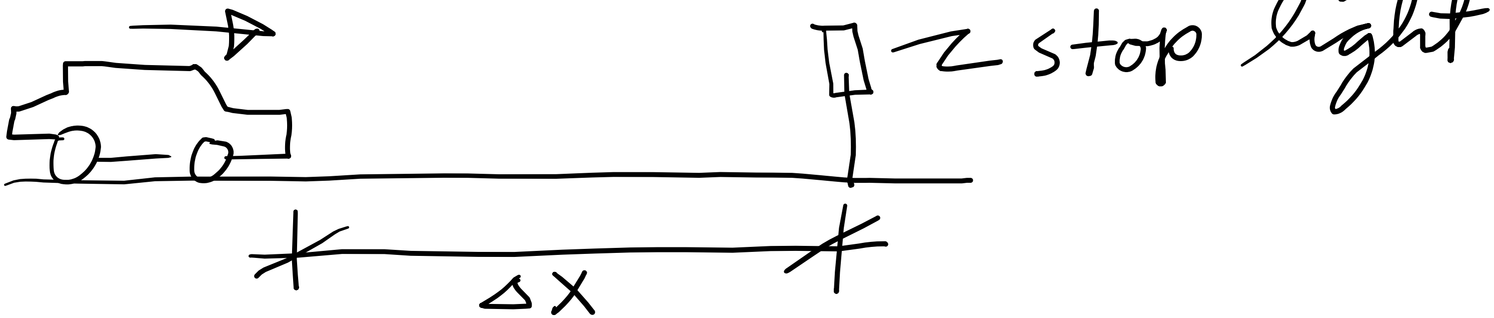


Given: $V_0 = 54\frac{km}{hr}$, $\Delta x = 240m$, $\Delta t = 24s$ & $a = const.$

(a) Find a: We know $x = \frac{1}{2}at^2 + V_0 t + x_0$

& Δx & Δt

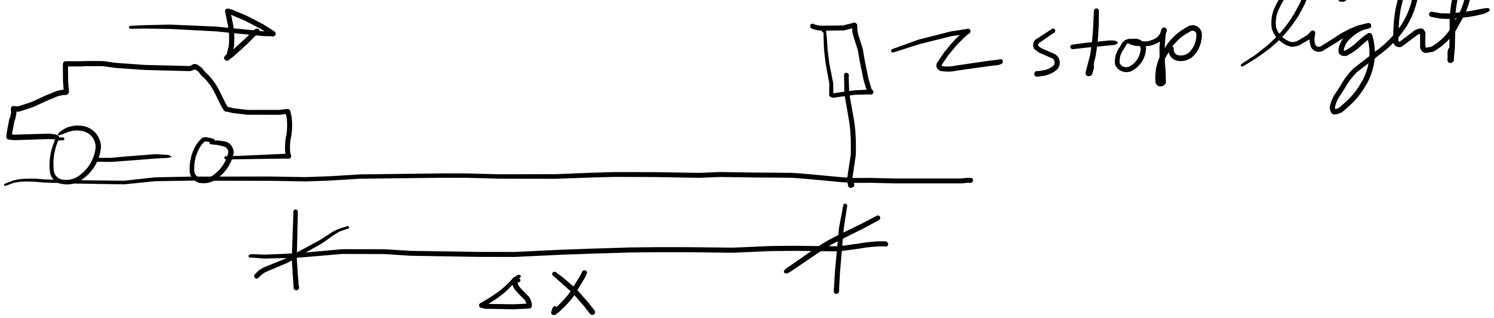
Notes on problems : $\boxed{11.34}$



Given: $V_0 = 54\frac{km}{hr}$, $\Delta x = 240m$, $\Delta t = 24s$ & $a = $ const.

(a) Find a: We know $x = \frac{1}{2}at^2 + V_0 t + x_0$ & Δx & Δt $\Rightarrow$ just need to dig out a

Notes on problems : $\boxed{11.34}$

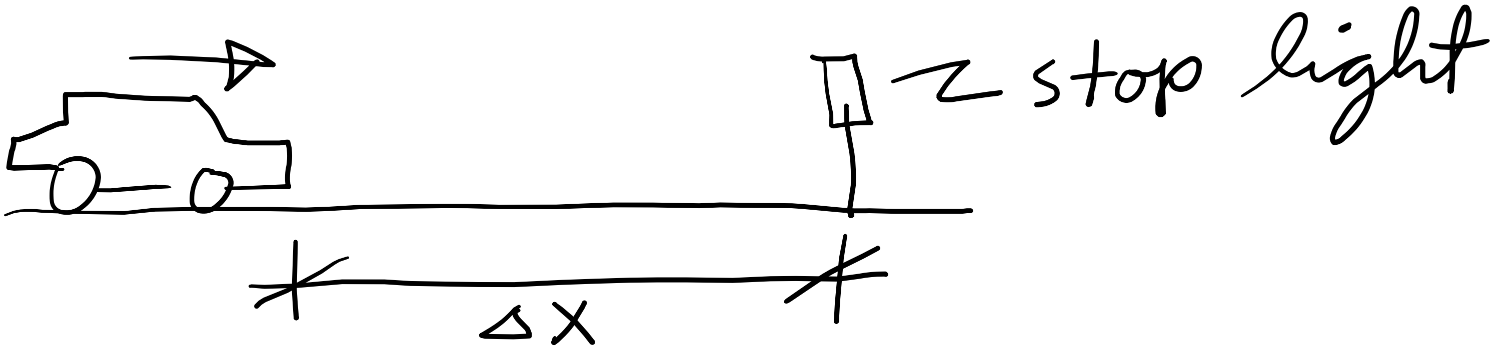


Given: $V_0 = 54\frac{km}{hr}$, $\Delta x = 240m$, $\Delta t = 24s$ & $a = const.$

(a) Find a: We know $x = \frac{1}{2}at^2 + V_0 t + x_0$ & Δx & Δt $\Rightarrow$ just need to dig out a

(b) Find v at $t = 24s$:

Notes on problems: $\boxed{11.34}$



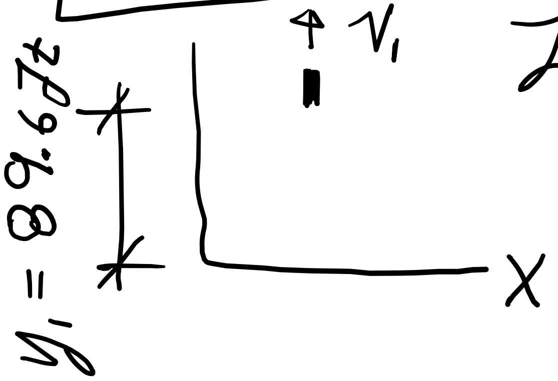
Given: $V_0 = 54\frac{km}{hr}$, $\Delta x = 240m$, $\Delta t = 24s$ & $a = const.$

(a) Find a: We know $x = \frac{1}{2}at^2 + V_0t + x_0$ & Δx & Δt $\Rightarrow$ just need to dig out a

(b) Find v at $t = 24s$: $v = \frac{dx}{dt} \Rightarrow$

$$v(t=24s) = \left.\frac{dx}{dt}\right|_{t=24s}$$

$\boxed{11.36}$



Lands 16s later

so
$$\begin{cases} y_1 = 89.6\,ft, & t_1 = 0 \\ y_f = 0\,ft, & t_f = 16\,s \\ a = -g = -32.2\,ft/s^2 & \end{cases}$$

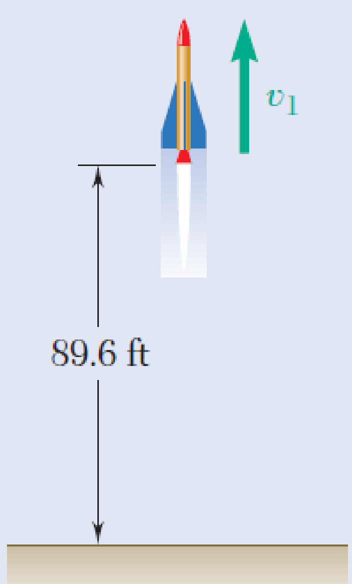
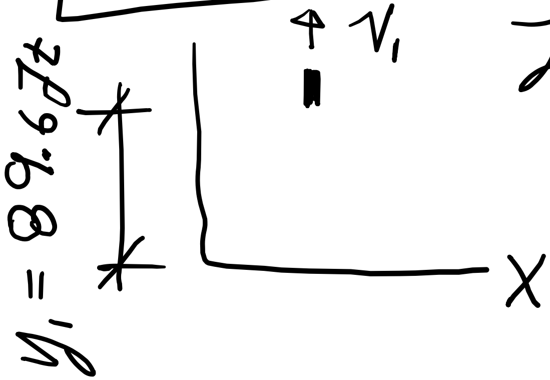


Fig. P11.36

11.36 A group of students launches a model rocket in the vertical direction. Based on tracking data, they determine that the altitude of the rocket was 89.6 ft at the end of the powered portion of the flight and that the rocket landed 16 s later. Knowing that the descent parachute failed to deploy so that the rocket fell freely to the ground after reaching its maximum altitude and assuming that $g = 32.2\ \text{ft/s}^2$, determine (*a*) the speed v_1 of the rocket at the end of powered flight, (*b*) the maximum altitude reached by the rocket.

$\boxed{11.36}$

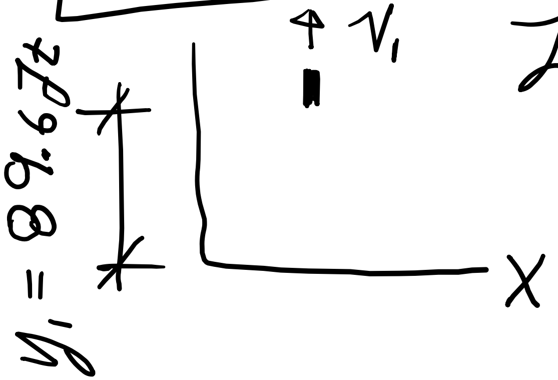


Lands 16s later

so
$$\begin{cases} y_1 = 89.6\,ft, & t_1 = 0 \\ y_f = 0\,ft, & t_f = 16\,s \\ a = -g = -32.2\,ft/s^2 \end{cases}$$

(a) Find v_1

$\boxed{11.36}$



Lands 16 s later

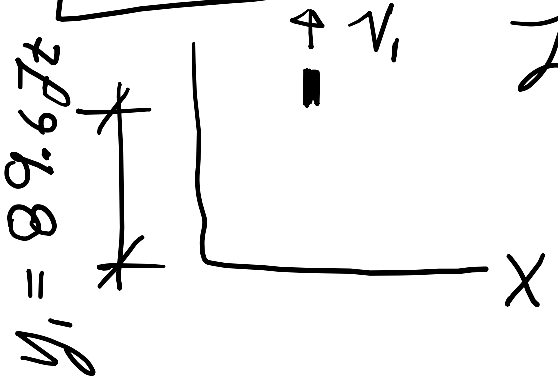
so

$$\begin{cases} y_1 = 89.6\,ft, & t_1 = 0 \\ y_F = 0\,ft, & t_F = 16\,s \\ a = -g = -32.2\,ft/s^2 \end{cases}$$

(a) Find v_1

$$y_F = -\frac{1}{2}gt^2 + v_1 t_F + y_1$$

$\boxed{11.36}$



Lands 16 s later

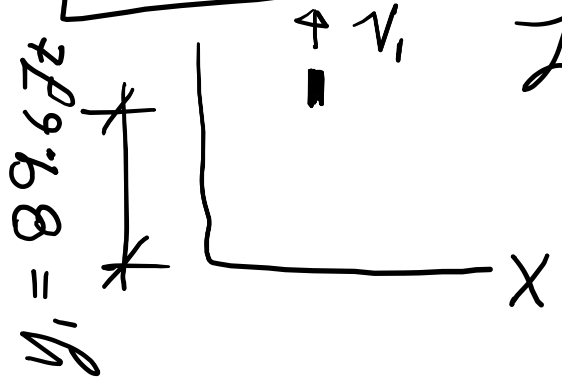
so
$$\begin{cases} y_1 = 89.6\,ft, & t_1 = 0 \\ y_F = 0\,ft, & t_F = 16\,s \\ a = -g = -32.2\,ft/s^2 \end{cases}$$

(a) Find v_1

$y_F = -\frac{1}{2} g t^2 + v_1 t_F + y_1$ we know t_F, y_F & y_1

so just need to dig out v_1

11.36



Lands 16s later

so
$$\begin{cases} y_1 = 89.6\,ft, & t_1 = 0 \\ y_F = 0\,ft, & t_f = 16s \\ a = -g = -32.2\,ft/s^2 & \end{cases}$$

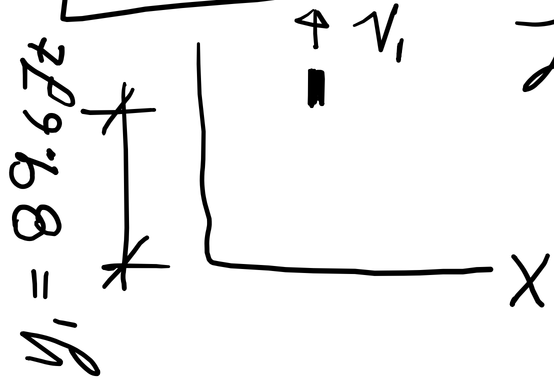
(a) Find v_1

$y_F = -\frac{1}{2}gt^2 + v_1 t_F + y_1$ we know t_F, y_F & y_1

so just need to dig out v_1

(b) Find y_{max}:

11.36



Lands 16 s later

so

$$\begin{cases} y_1 = 89.6\,ft, & t_1 = 0 \\ y_F = 0\,ft, & t_F = 16\,s \\ a = -g = -32.2\,ft/s^2 \end{cases}$$

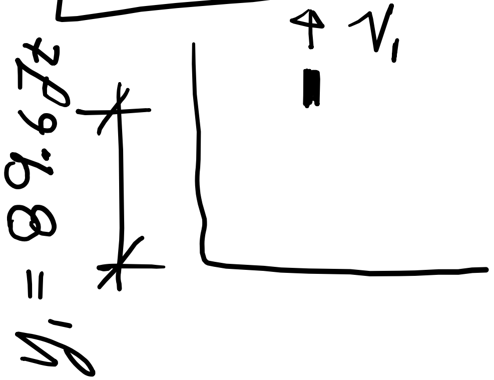
(a) Find v_1

$y_F = -\frac{1}{2}gt^2 + v_1 t_F + y_1$ we know t_F, y_F & y_1

so just need to dig out v_1

(b) Find y_{MAX} : 2 ways

11.36



Lands 16s later

so

$$\begin{cases} y_1 = 89.6\,ft, & t_1 = 0 \\ y_F = 0\,ft, & t_f = 16\,s \\ a = -g = -32.2\,ft/s^2 \end{cases}$$

(a) Find v_1

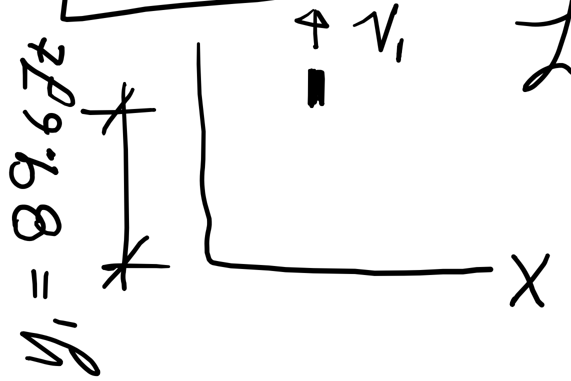
$y_F = -\frac{1}{2} g t^2 + v_1 t_F + y_1$ we know t_F, y_F & y_1

so just need to dig out v_1

(b) Find y_{max} : 2 ways: ① y_{max} when $v = 0$

$\Rightarrow$ Find t at $v = 0$ then use t to get y_{max}

$\boxed{11.36}$



Lands 16s later

so
$$\begin{cases} y_1 = 89.6\,ft\,, & t_1 = 0 \\ y_F = 0\,ft\,, & t_f = 16s \\ a = -g = -32.2\,ft/s^2 \end{cases}$$

<u>(a) Find v_1</u>

$y_F = -\frac{1}{2}gt^2 + v_1 t_F + y_1$ we know t_F, y_F & y_1

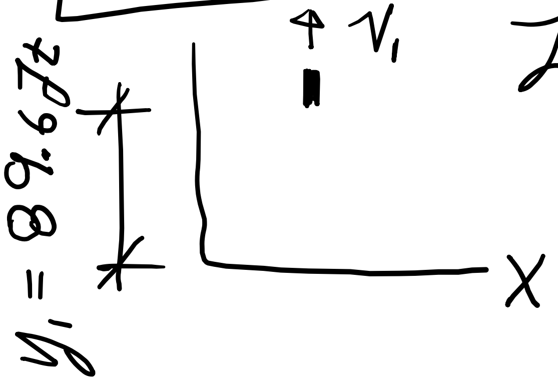
so just need to dig out v_1

<u>(b) Find y_{MAX} :</u> 2 ways: ① y_{MAX} when $v = 0$

$\Rightarrow$ Find t at $v = 0$ then use t to get y_{MAX} <u>or</u>

② Use $a = v\frac{dv}{dy} \Rightarrow -g = v\frac{dv}{dy}$

$\boxed{11.36}$



Lands 16 s later

so $\begin{cases} y_1 = 89.6\text{ ft},\ t_1 = 0 \\ y_F = 0\text{ ft},\ t_f = 16\text{ s} \\ a = -g = -32.2\text{ ft/s}^2 \end{cases}$

(a) Find V_1

$y_F = -\frac{1}{2} g t^2 + V_1 t_F + y_1$ we know t_F, y_F & y_1 so just need to dig out V_1

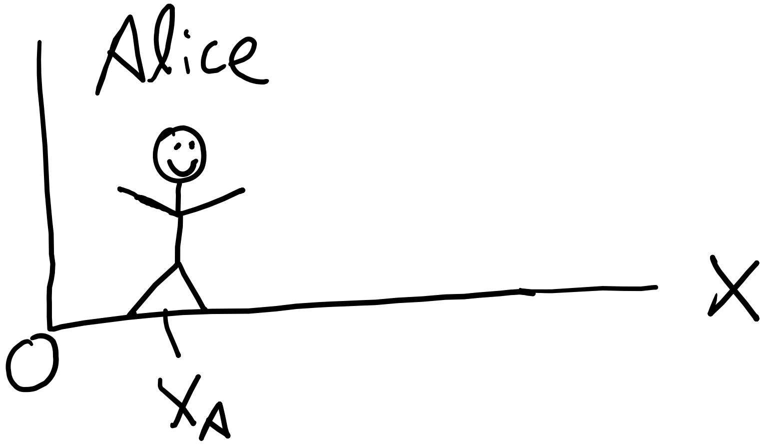
(b) Find y_{MAX}: 2 ways: ① y_{MAX} when $V = 0$ $\Rightarrow$ find t at $V = 0$ then use t to get y_{MAX} or

② Use $a = V\frac{dV}{dy} \Rightarrow -g = V\frac{dV}{dy} \Rightarrow -g\,dy = V\,dV$

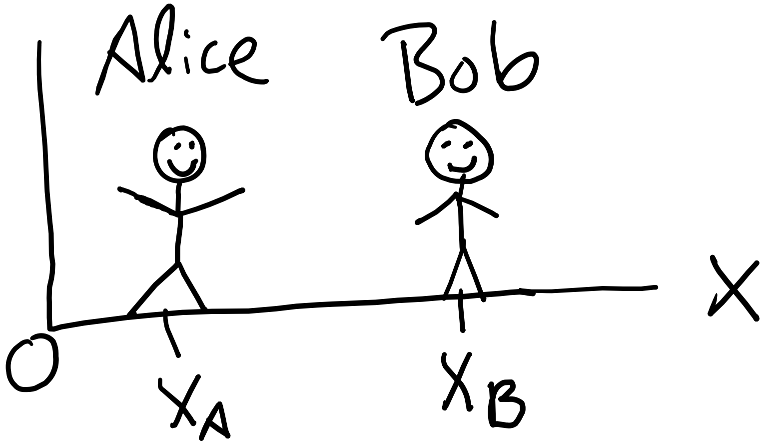
$$\Rightarrow -g\int_{y_1}^{y_{MAX}} dy = \int_{V_1}^{V=0} V\,dV$$

Relative motion

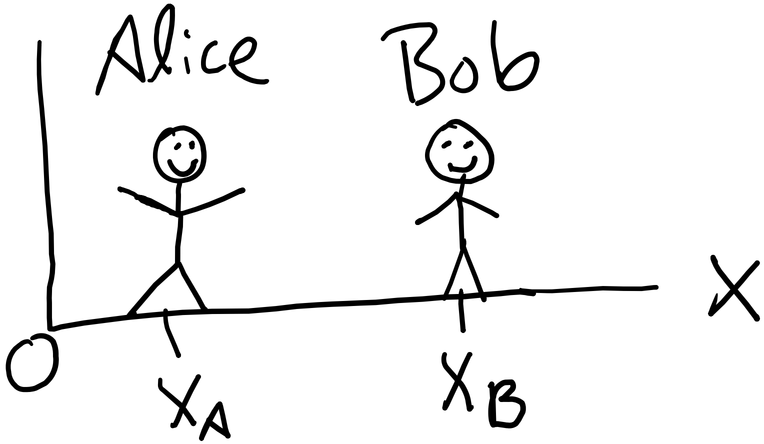
Relative motion



Relative motion



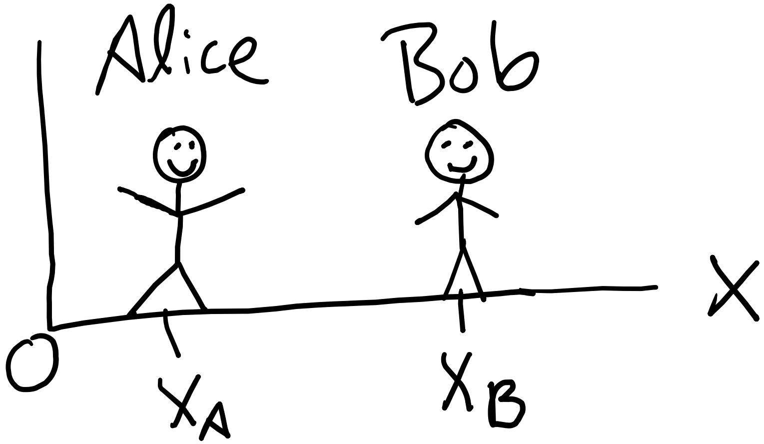
Relative motion



position:

$x_{B/A} \equiv$ x of B relative to A

Relative motion



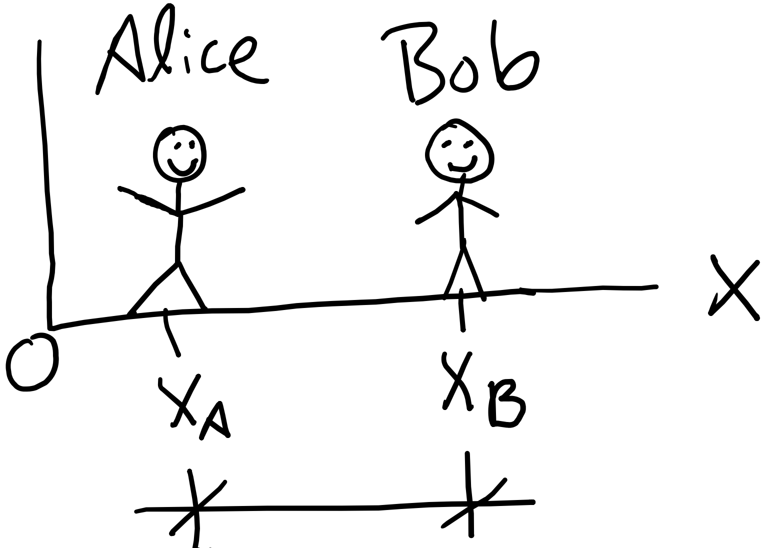
position:

$x_{B/A} \equiv$ x of B relative to A

& $x_{B/A} \equiv x_B - x_A$

ASU

Relative motion



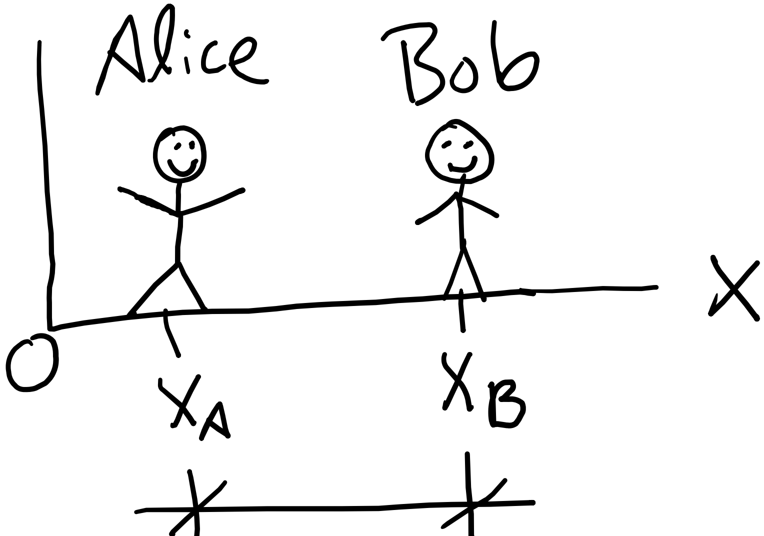
$$x_{B/A} = x_B - x_A$$

position:

$x_{B/A} \equiv x$ of B relative to A

& $x_{B/A} \equiv x_B - x_A$

Relative motion



$x_{B/A} = x_B - x_A$

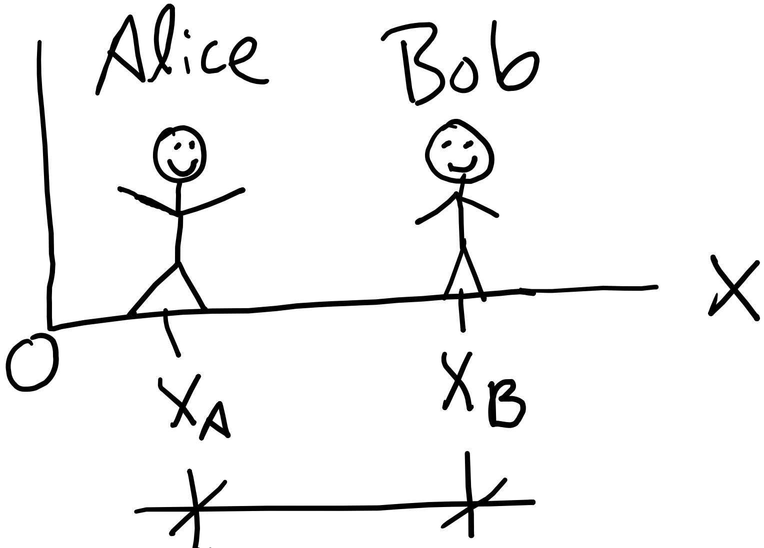
position:

$x_{B/A} \equiv$ x of B relative to A

& $x_{B/A} \equiv x_B - x_A$

Velocity:

Relative motion



$x_{B/A} = x_B - x_A$

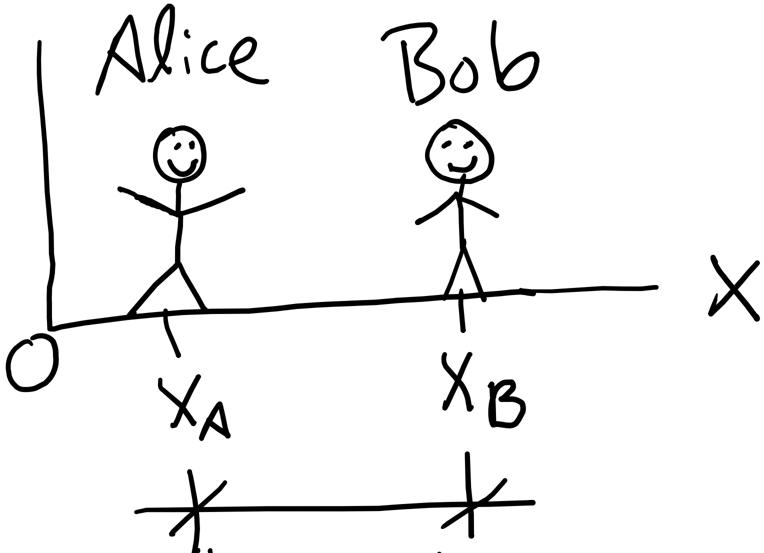
position:

$x_{B/A} \equiv$ x of B relative to A

& $x_{B/A} \equiv x_B - x_A$

Velocity: $v_{B/A} = v_B - v_A$

Relative motion



$$x_{B/A} = x_B - x_A$$

position:

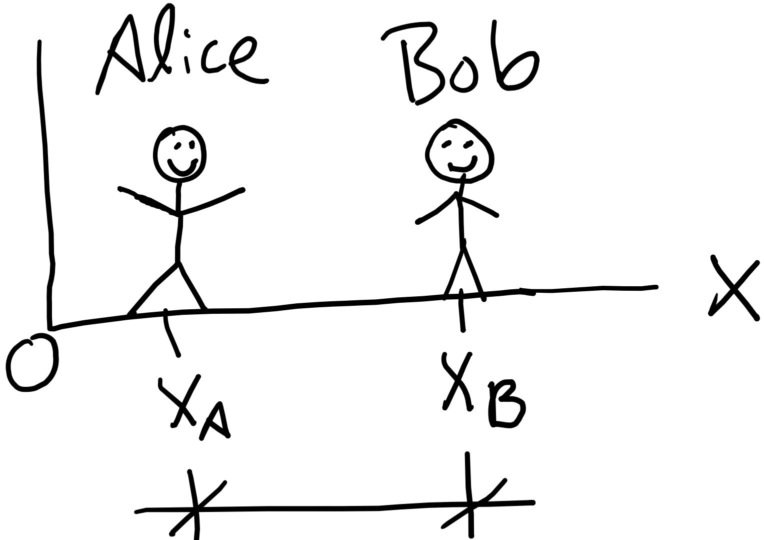
$x_{B/A} \equiv x$ of B relative to A

& $x_{B/A} \equiv x_B - x_A$

Velocity: $v_{B/A} = v_B - v_A$

acceleration:

Relative motion



$$x_{B/A} = x_B - x_A$$

position:

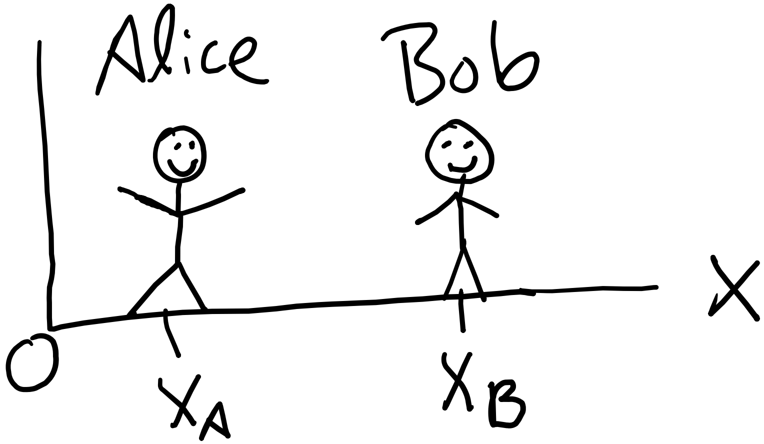
$x_{B/A} \equiv$ x of B relative to A

& $x_{B/A} \equiv x_B - x_A$

Velocity: $v_{B/A} = v_B - v_A$

acceleration: $a_{B/A} = a_B - a_A$

Relative motion



$$x_{B/A} = x_B - x_A$$

position:

$x_{B/A} \equiv$ x of B relative to A

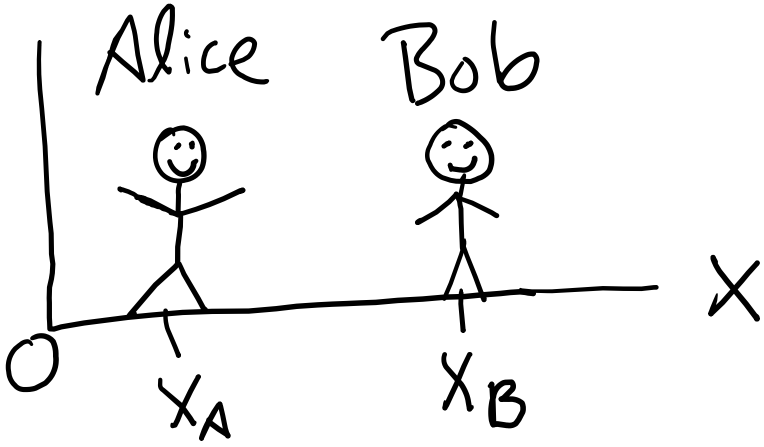
& $x_{B/A} \equiv x_B - x_A$

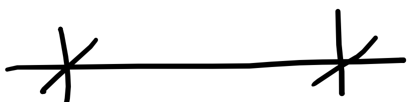
Velocity: $v_{B/A} = v_B - v_A$

acceleration: $a_{B/A} = a_B - a_A$

Note: $v_{B/A} = \dfrac{dx_{B/A}}{dt}$

Relative motion





$x_{B/A} = x_B - x_A$

position:

$x_{B/A} \equiv$ x of B relative to A

& $x_{B/A} \equiv x_B - x_A$

Velocity: $v_{B/A} = v_B - v_A$

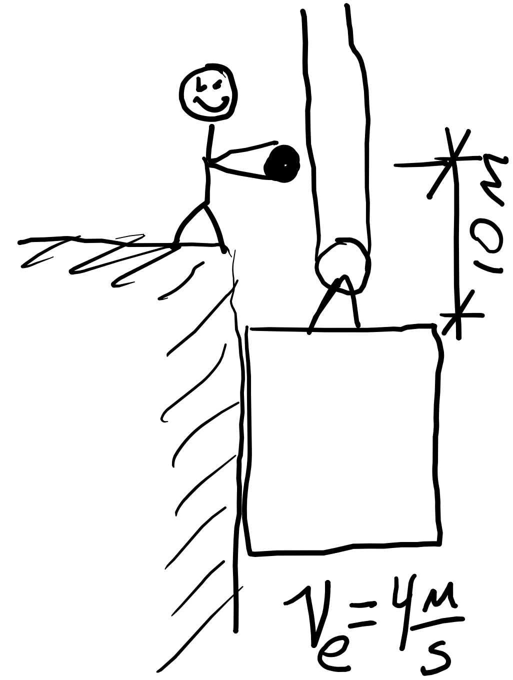
acceleration: $a_{B/A} = a_B - a_A$

Note: $v_{B/A} = \dfrac{dx_{B/A}}{dt}$ & $a_{B/A} = \dfrac{dv_{B/A}}{dt}$

Notes on problem 11.44:

Notes on problem 11.44:

Man throws ball up with initial velocity of $V_{bI} = 3\frac{m}{s}$



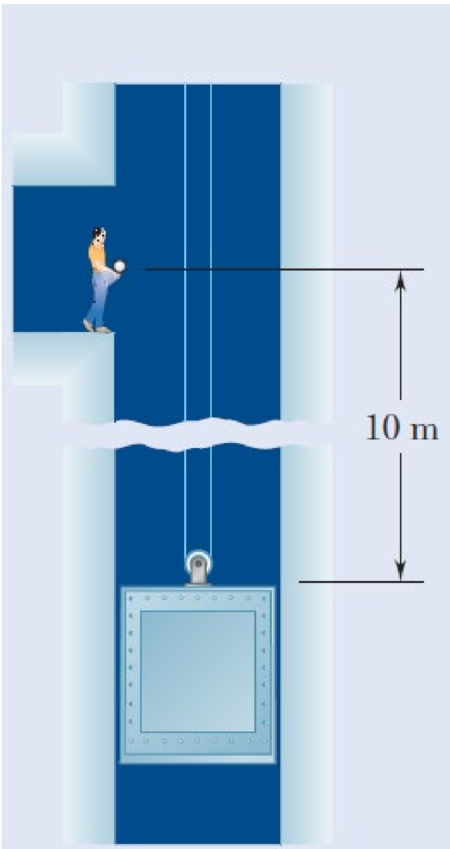
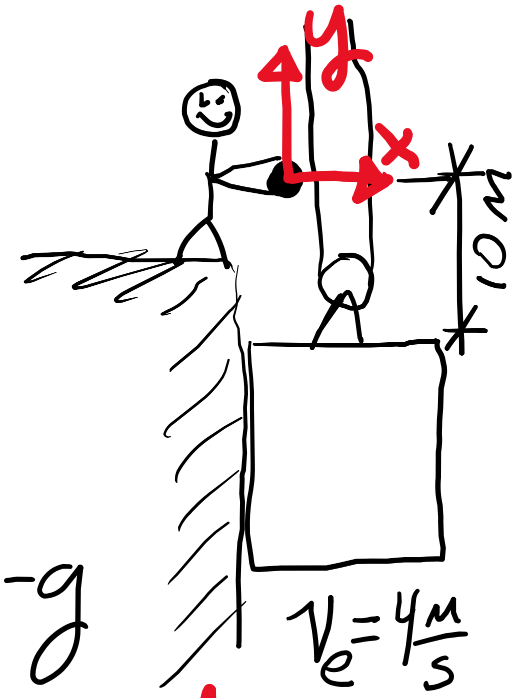


Fig. P11.44

11.44 An elevator is moving upward at a constant speed of 4 m/s. A man standing 10 m above the top of the elevator throws a ball upward with a speed of 3 m/s. Determine (*a*) when the ball will hit the elevator, (*b*) where the ball will hit the elevator with respect to the location of the man.

Notes on problem 11.44:

Man throws ball up with initial velocity of $v_{bI} = 3\frac{m}{s}$



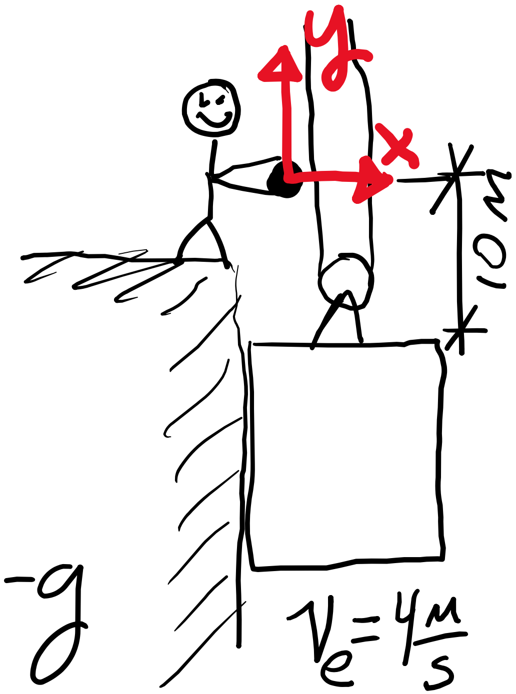
so $\begin{cases} v_e = 4 m/s, & y_{eo} = -10m \\ v_{bo} = 3\frac{m}{s}, & y_{bo} = 0m \end{cases}$ & $a_b = -g$

Note: Setting coordinate system at initial position of ball

Notes on problem 11.44:

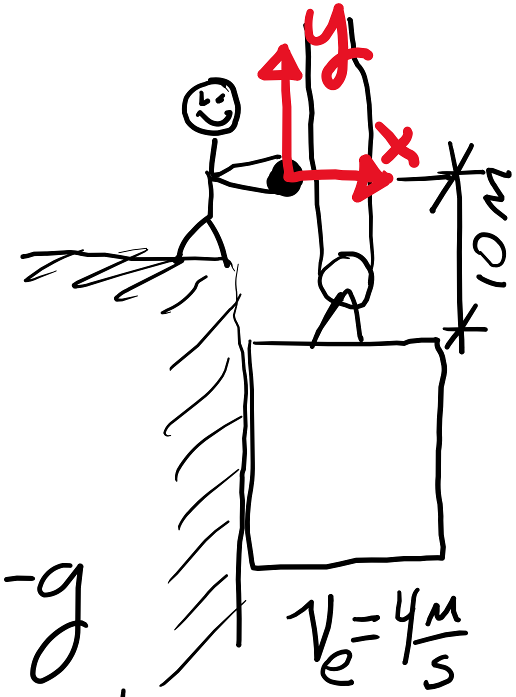
Man throws ball up with initial velocity of $v_{bI} = 3\frac{m}{s}$

so $\begin{cases} v_e = 4\,m/s, & y_{eo} = -10\,m \\ v_{bo} = 3\frac{m}{s}, & y_{bo} = 0\,m \end{cases}$ & $a_b = -g$



Can write $y_b = -\frac{1}{2}gt^2 + v_{bo}t + y_{bo}$

Notes on problem 11.44:

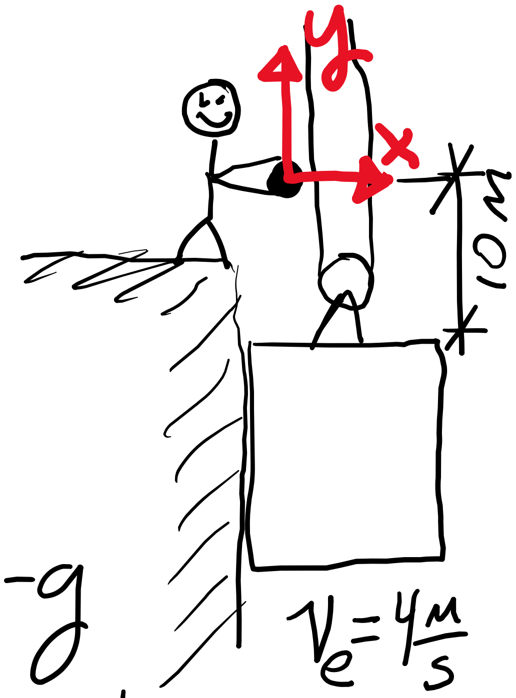


Man throws ball up with initial velocity of $V_{bI} = 3\frac{m}{s}$

so $\begin{cases} V_e = 4 m/s, & y_{eo} = -10 m \\ V_{bo} = 3\frac{m}{s}, & y_{bo} = 0 m \end{cases}$ & $a_b = -g$

Can write $y_b = -\frac{1}{2}gt^2 + V_{bo}t + y_{bo}$ & $y_e = V_e t + y_{eo}$

Notes on problem 11.44:



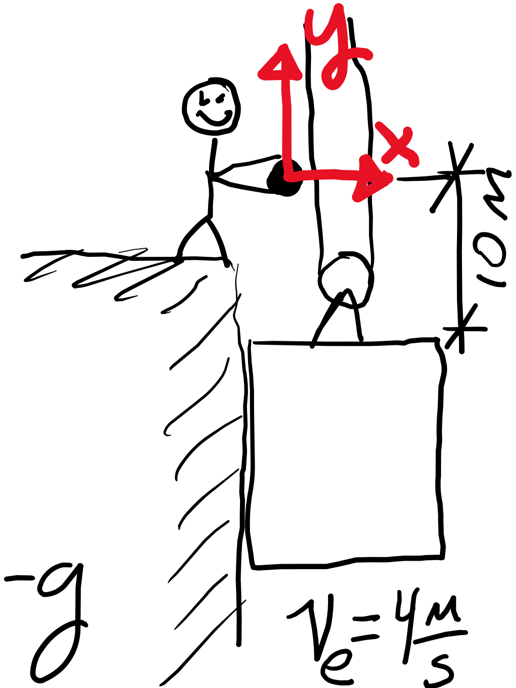
Man throws ball up with initial velocity of $V_{bI} = 3\frac{m}{s}$

so $\begin{cases} V_e = 4 m/s, \; y_{eo} = -10m \\ V_{bo} = 3\frac{m}{s}, \; y_{bo} = 0m \end{cases}$ & $a_b = -g$

Can write $y_b = -\frac{1}{2}gt^2 + V_{bo}t + y_{bo}$ & $y_e = V_e t + y_{eo}$

(a) Find t at hit $\equiv t_h$:

Notes on problem 11.44:



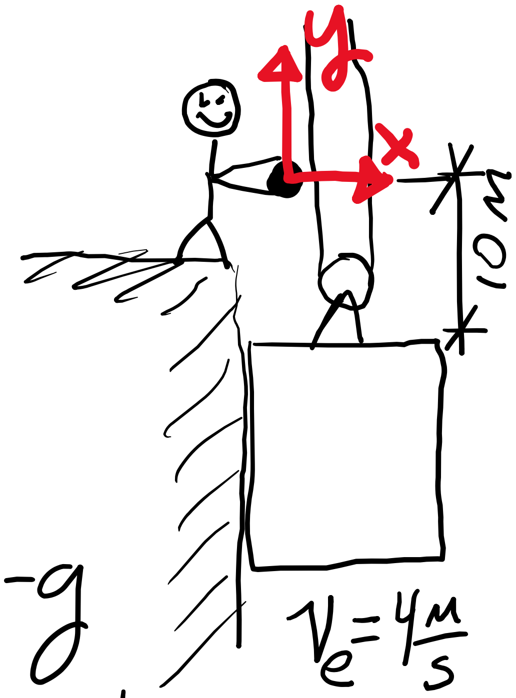
Man throws ball up with initial velocity of $V_{bI} = 3\frac{m}{s}$

so $\begin{cases} V_e = 4\,m/s, & y_{eo} = -10\,m \\ V_{bo} = 3\frac{m}{s}, & y_{bo} = 0\,m \end{cases}$ & $a_b = -g$

Can write $y_b = -\frac{1}{2}gt^2 + V_{bo}t + y_{bo}$ & $y_e = V_e t + y_{eo}$

(a) Find t at hit $\equiv t_h$: Note: $y_{b/e} = 0$ at t_h so just need to dig out t_h

Notes on problem 11.44:



Man throws ball up with initial velocity of $v_{b_I} = 3\frac{m}{s}$

so $\begin{cases} v_e = 4\,m/s, & y_{eo} = -10\,m \\ v_{bo} = 3\frac{m}{s}, & y_{bo} = 0\,m \end{cases}$ & $a_b = -g$

Can write $y_b = -\frac{1}{2}gt^2 + v_{bo}t + y_{bo}$ & $y_e = v_e t + y_{eo}$

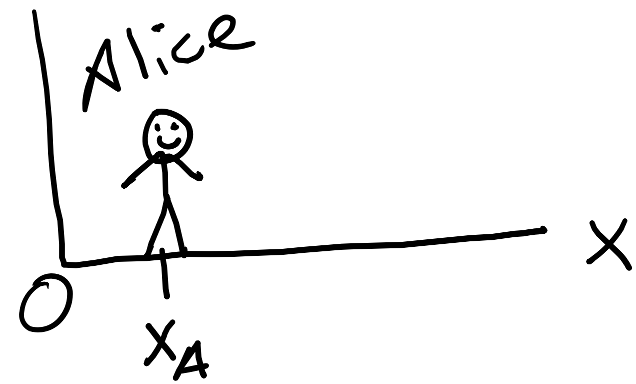
(a) Find t at hit $\equiv t_h$: Note: $y_{b/e} = \emptyset$ at t_h so just need to dig out t_h

(b) Find $y_e(t_h)$ or $y_b(t_h)$: Since $y_{b/e} = \emptyset$

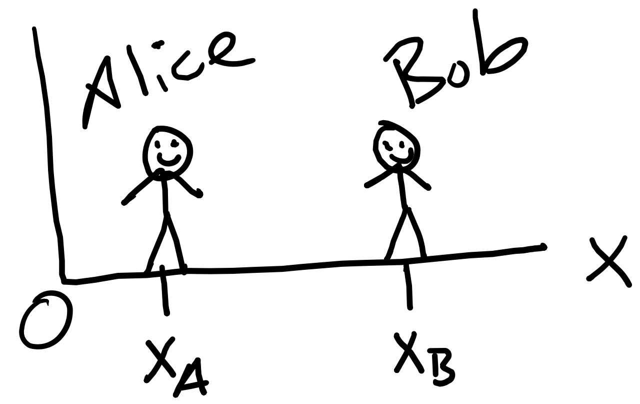
$\Rightarrow y_b = y_e$

Relative motion

Relative motion



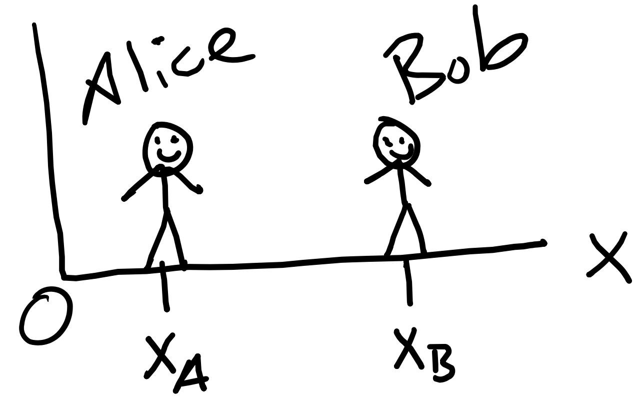
Relative motion



Relative motion

position:

$x_{B/A} \equiv$ x of B relative to A

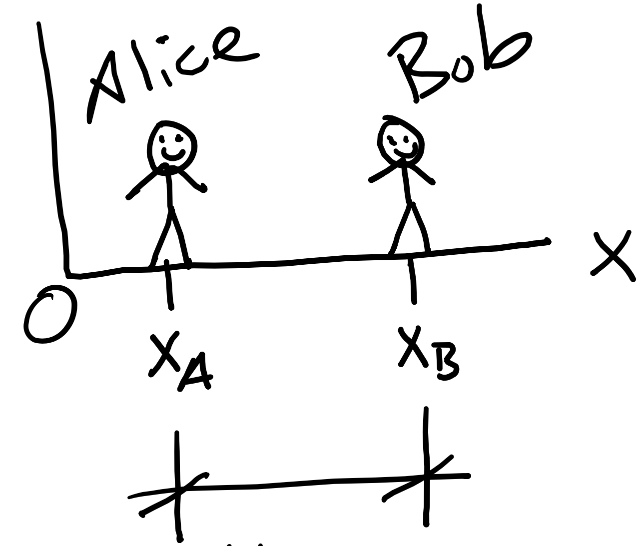


Relative motion

position:

$x_{B/A} \equiv$ x of B relative to A

$x_{B/A} \equiv x_B - x_A$



$x_{B/A} = x_B - x_A$

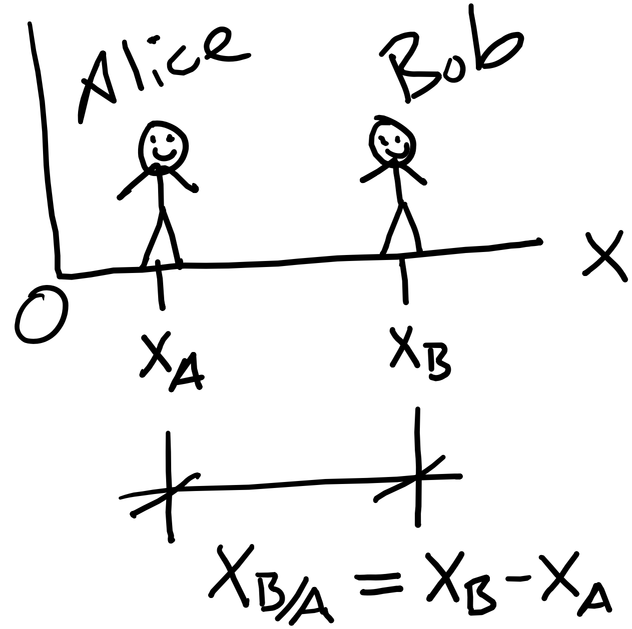
Relative motion

position:

$x_{B/A} \equiv x$ of B relative to A

$x_{B/A} \equiv x_B - x_A$

$x_{B/A}$ is position of Bob as measured by Alice



Relative motion

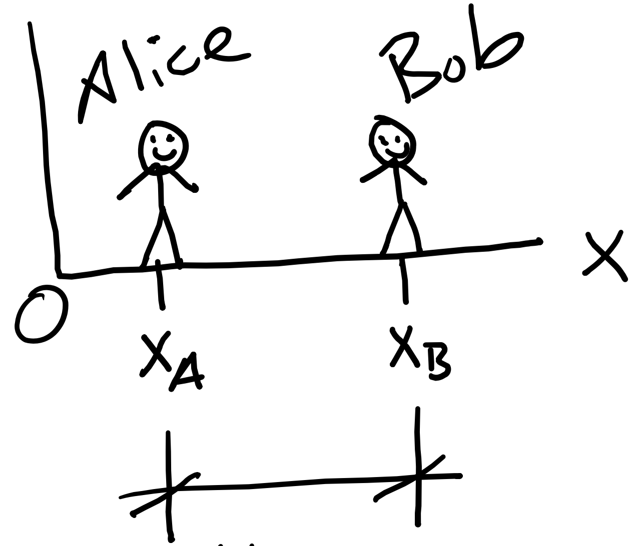
position:

$x_{B/A} \equiv x$ of B relative to A

$x_{B/A} \equiv x_B - x_A$

$x_{B/A}$ is position of Bob as measured by Alice

Velocity: $v_{B/A} = v_B - v_A$



$x_{B/A} = x_B - x_A$

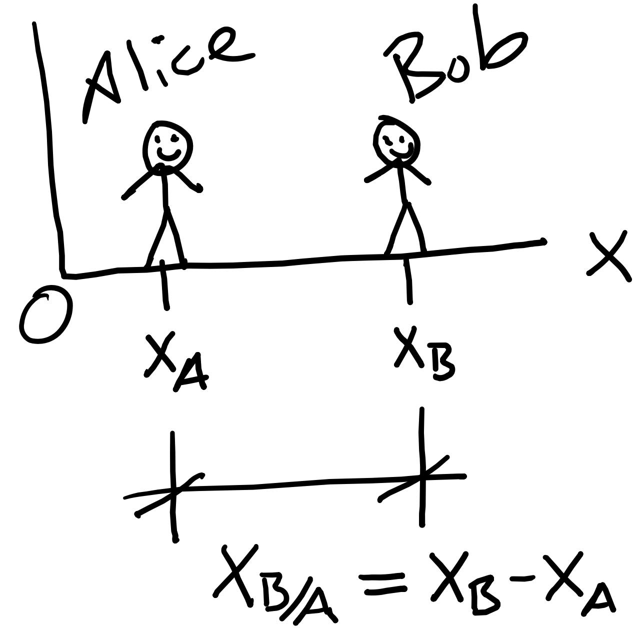
Relative motion

position:

$x_{B/A} \equiv$ x of B relative to A

$x_{B/A} \equiv x_B - x_A$

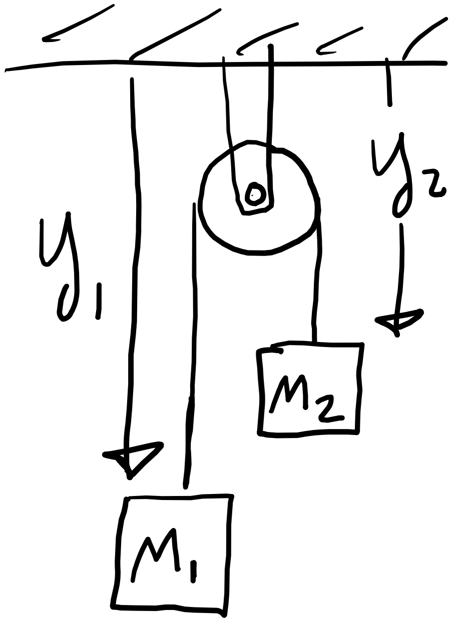
$x_{B/A}$ is position of Bob as measured by Alice



Velocity: $v_{B/A} = v_B - v_A$

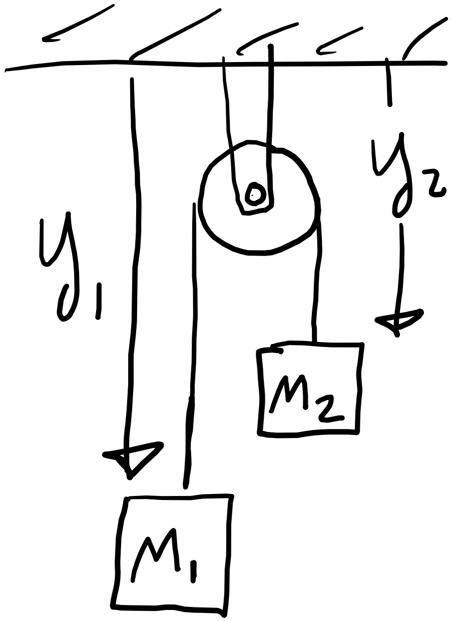
acceleration: $a_{B/A} = a_B - a_A$

Pulley problems



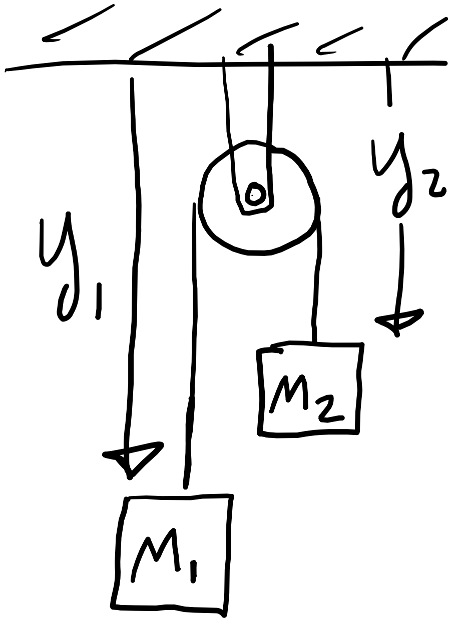
← Super simple example

Pulley problems



For these problems we tend to want the velocity $\frac{dy_i}{dt}$ and/or acceleration $\frac{d^2y_i}{dt^2}$

Pulley problems

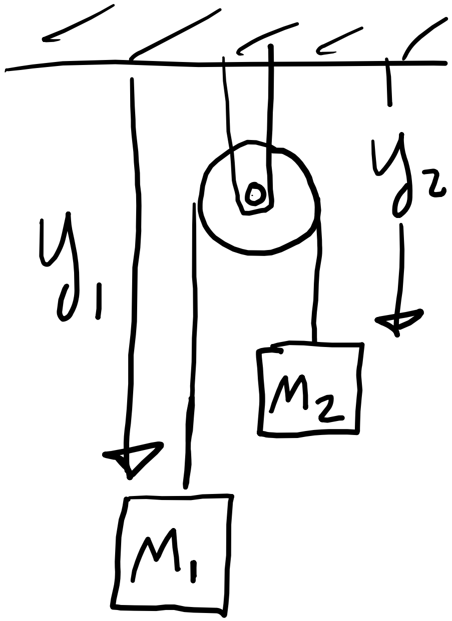


For these problems we tend to want the velocity $\frac{dy_i}{dt}$ and/or acceleration $\frac{d^2y_i}{dt^2}$

Note: If length of rope $\equiv \ell$

& $\ell = y_1 + y_2 +$ constant

Pulley problems



For these problems we tend to want the velocity $\frac{dy_i}{dt}$ and/or acceleration $\frac{d^2y_i}{dt^2}$

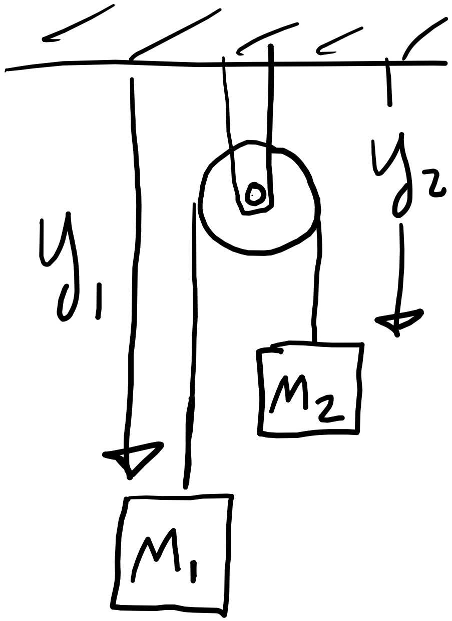
Note: If length of rope $\equiv l$

& $l = y_1 + y_2 + \text{constant}$ then

$$\frac{d}{dt} l = \frac{d}{dt}[y_1 + y_2 + \text{constant}] \Rightarrow$$

$$0 = V_1 + V_2$$

Pulley problems



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Note: If length of rope $\equiv \ell$

& $\ell = y_1 + y_2 + \text{constant}$ then

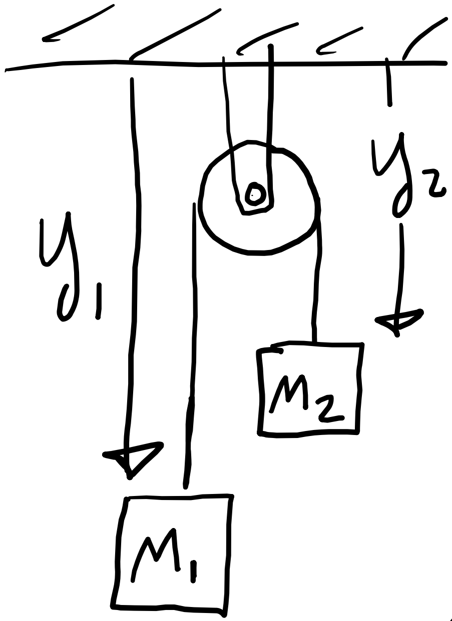
$$\frac{d}{dt}\ell = \frac{d}{dt}[y_1 + y_2 + \text{constant}] \Rightarrow$$

$$0 = V_1 + V_2 \Rightarrow V_1 = -V_2$$

As expected ☺

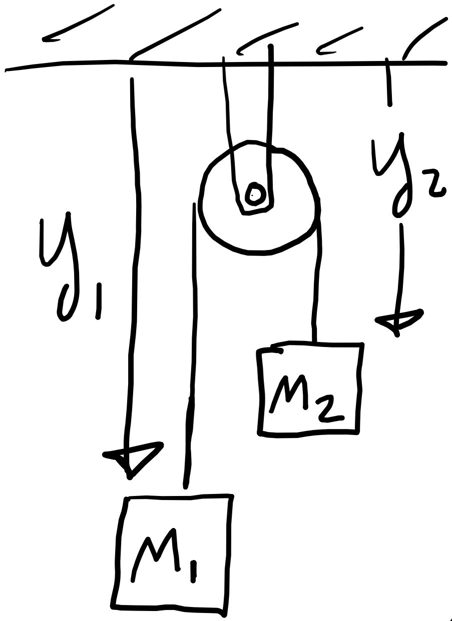
ASU

Pulley problems



We can relate y_1 & y_2 to length of rope (l) & take time derivitive to get rid of any constant lengths [like length l of rope]

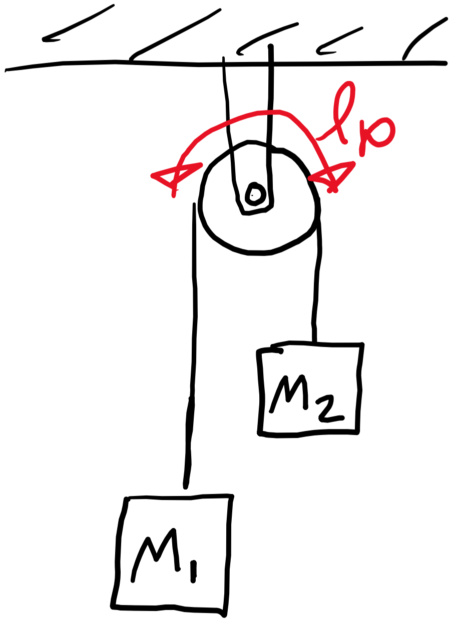
Pulley problems



We can relate y_1 & y_2 to length of rope (ℓ) & take time derivitive to get rid of any constant lengths [like length ℓ of rope]

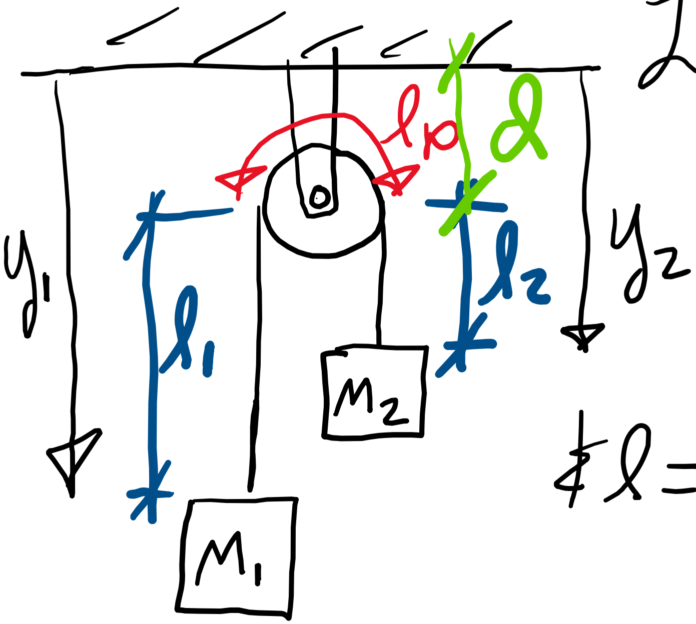
With some practice, we can get fairly quick at these kind of calculations ☺

Pulley problems



Let $l_p \equiv$ length of rope along pulley

Pulley problems

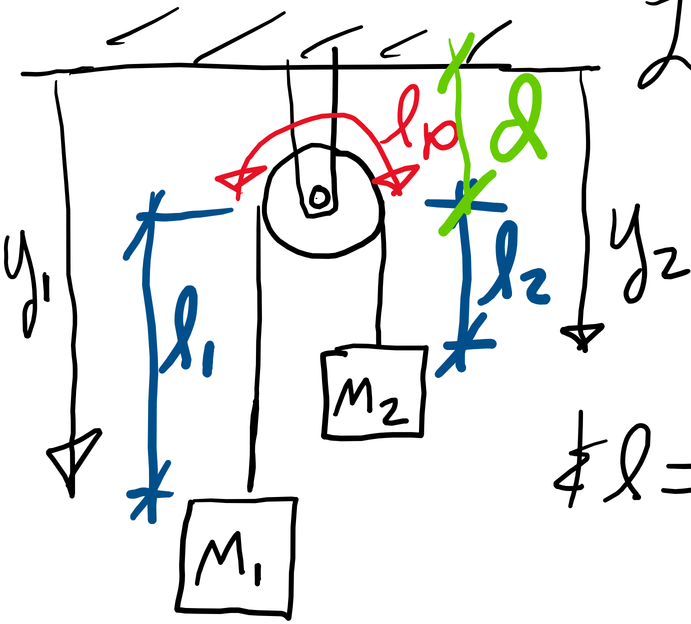


Let $l_p \equiv$ length of rope along pulley

Total length of rope $\equiv l$

$\& \; l = l_1 + l_p + l_2$

Pulley problems

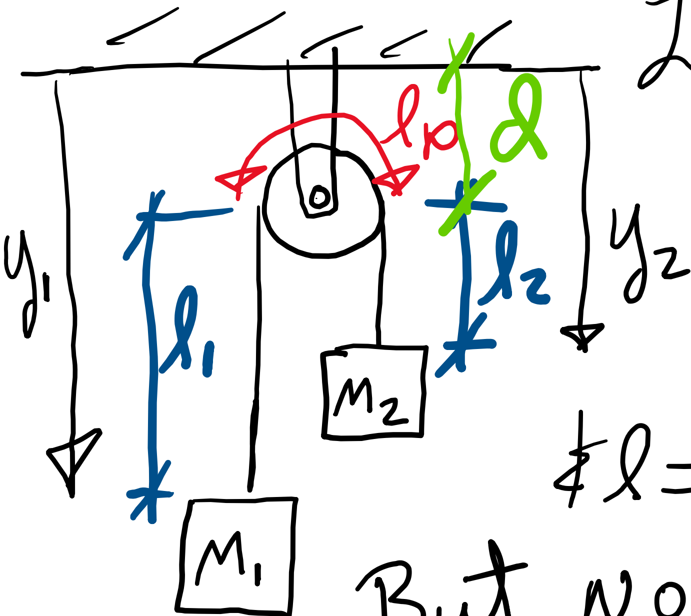


Let $l_p \equiv$ length of rope along pulley

Total length of rope $\equiv l$

& $l = l_1 + l_p + l_2$ or $l = (y_1 - d) + l_p + (y_2 - d)$

Pulley problems



Let $\ell_p \equiv$ length of rope along pulley

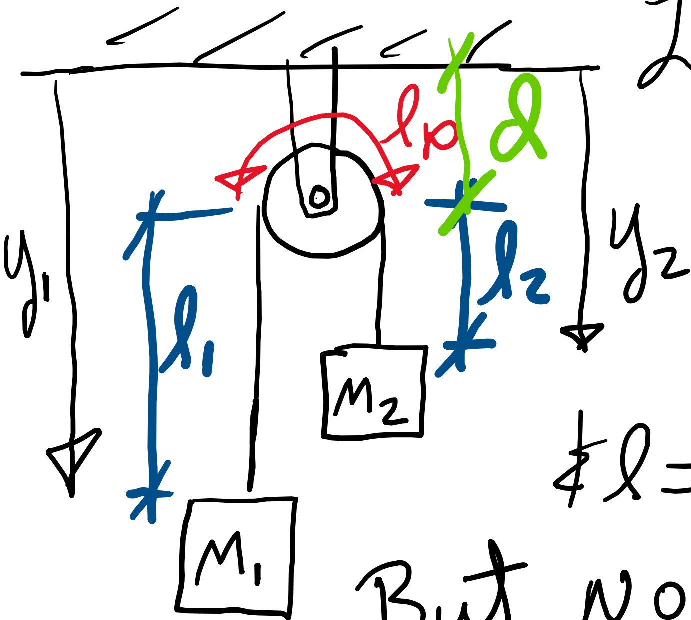
Total length of rope $\equiv \ell$

& $\ell = \ell_1 + \ell_p + \ell_2$ <u>or</u> $\ell = (y_1 - d) + \ell_p + (y_2 - d)$

<u>But</u> no matter how m_1 & M_2 move

ℓ_p & d do not change

Pulley problems



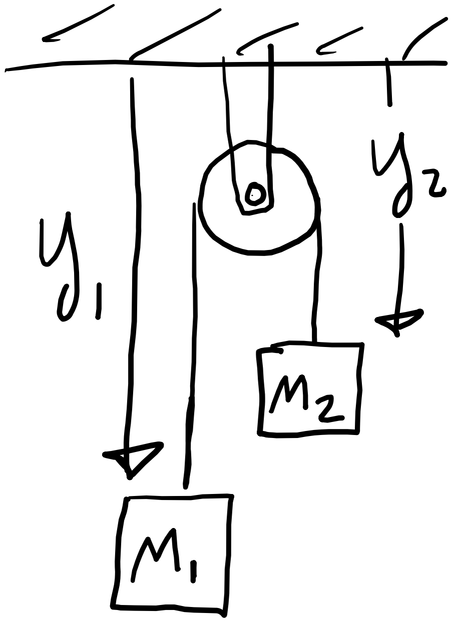
Let $l_p \equiv$ length of rope along pulley

Total length of rope $\equiv l$

& $l = l_1 + l_p + l_2$ **or** $l = (y_1 - d) + l_p + (y_2 - d)$

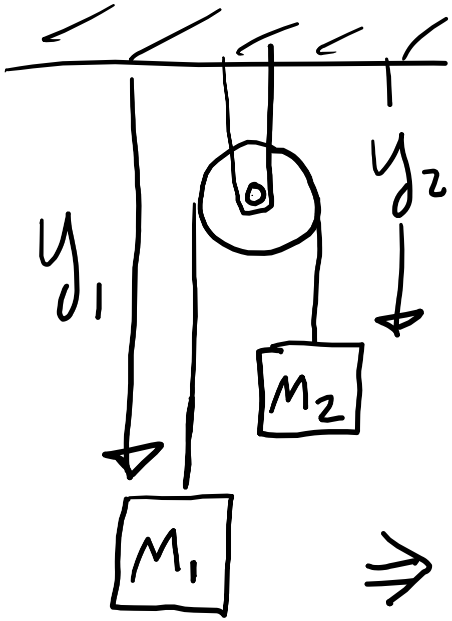
But no matter how m_1 & M_2 move l_p & d do not change. Could simply write $y_1 + y_2 = \text{constant}$ ☺

Pulley problems



We simply neglect those parts of rope that are constant.

Pulley problems

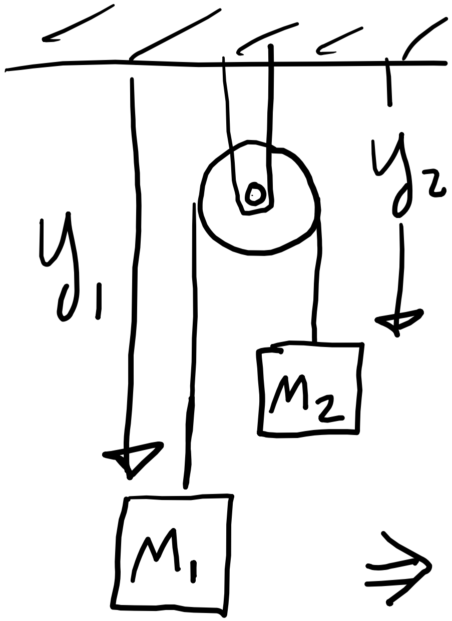


We simply neglect those parts of rope that are constant. As stated before

$$\frac{d}{dt}[y_1 + y_2] = \frac{d}{dt}[\text{const}]$$

$$\Rightarrow \quad v_1 = -v_2$$

Pulley problems

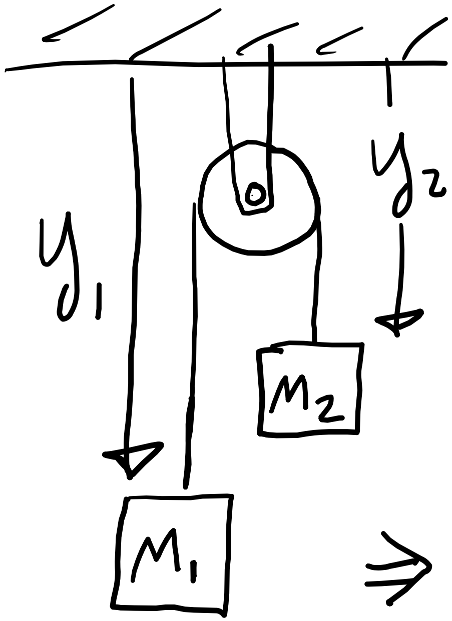


We simply neglect those parts of rope that are constant. As stated before $\frac{d}{dt}[y_1+y_2] = \frac{d}{dt}[\text{const}]$

$\Rightarrow \quad V_1 = -V_2$

But we already knew that by just looking at the picture

Pulley problems



We simply neglect those parts of rope that are constant. As stated before $\frac{d}{dt}[y_1+y_2] = \frac{d}{dt}[\text{const}]$

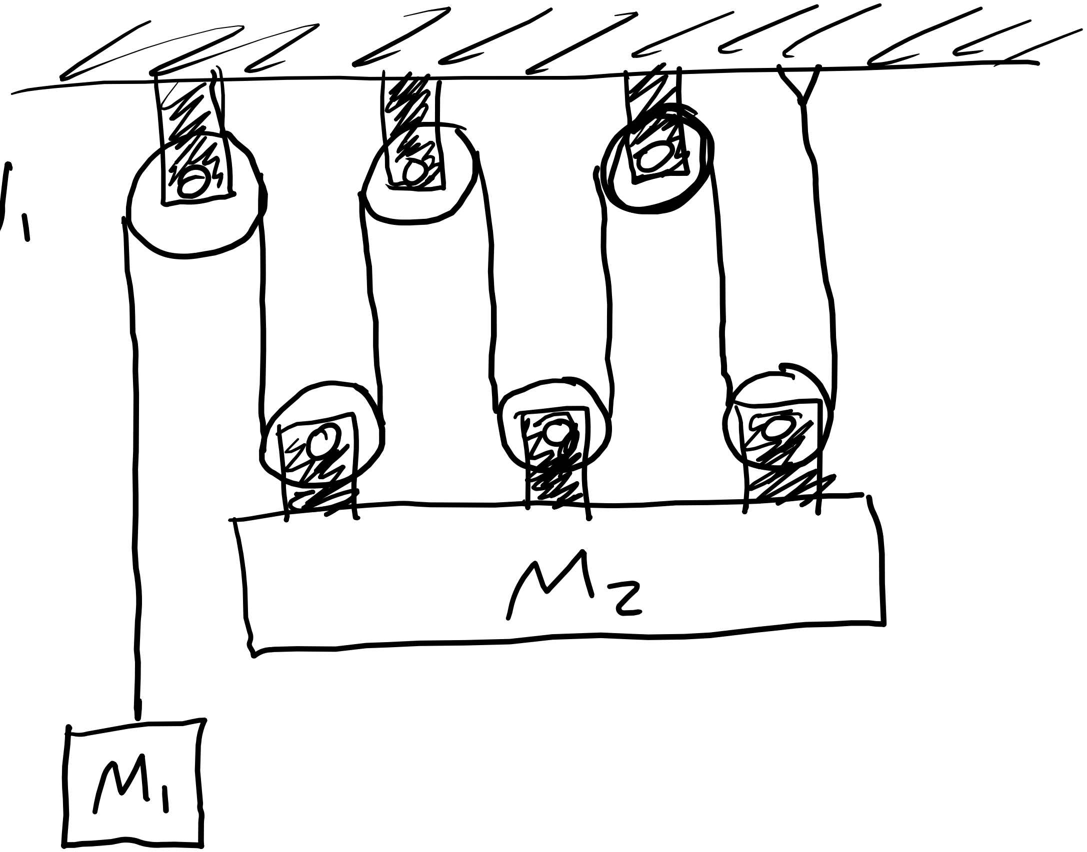
$\Rightarrow \quad V_1 = -V_2$

But we already knew that by just looking at the picture

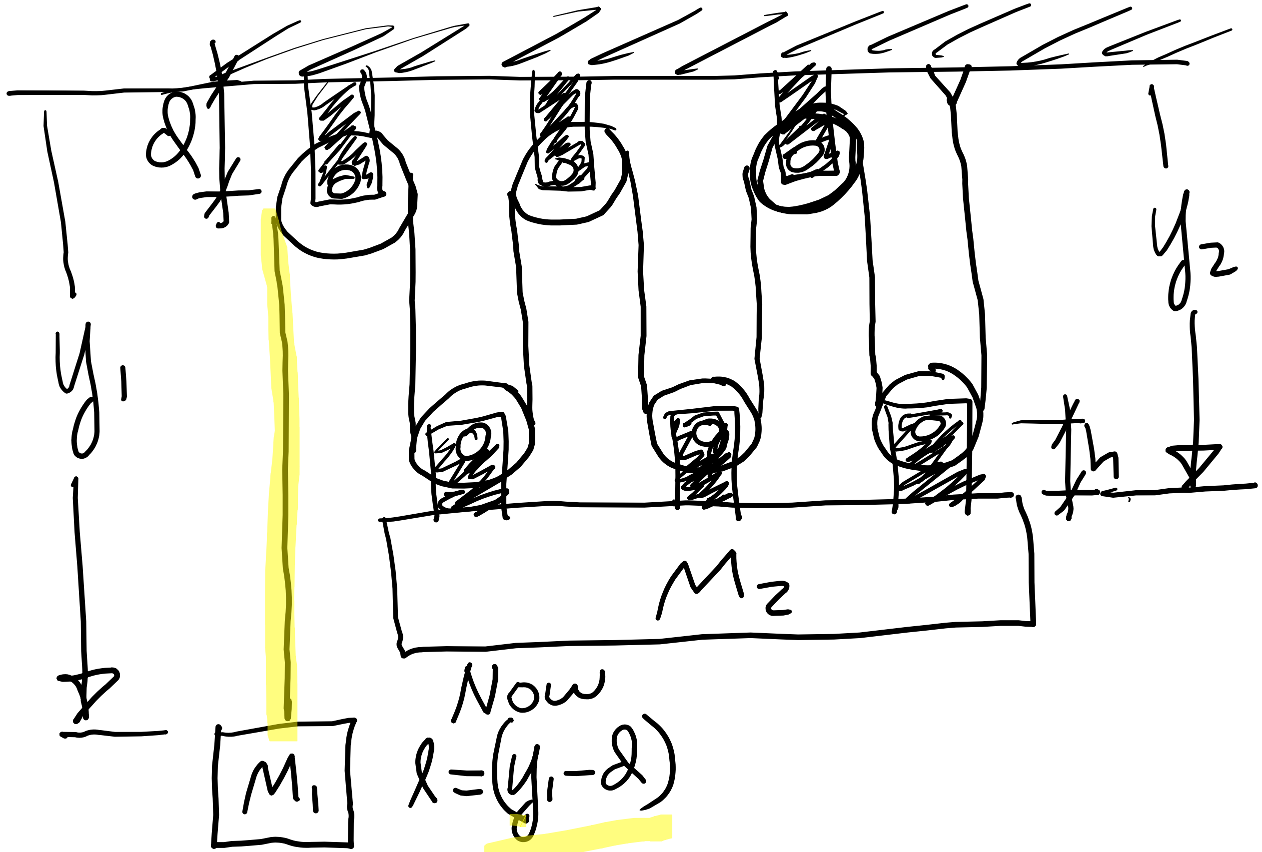
More difficult problem →

Another example

Find v_2 given v_1



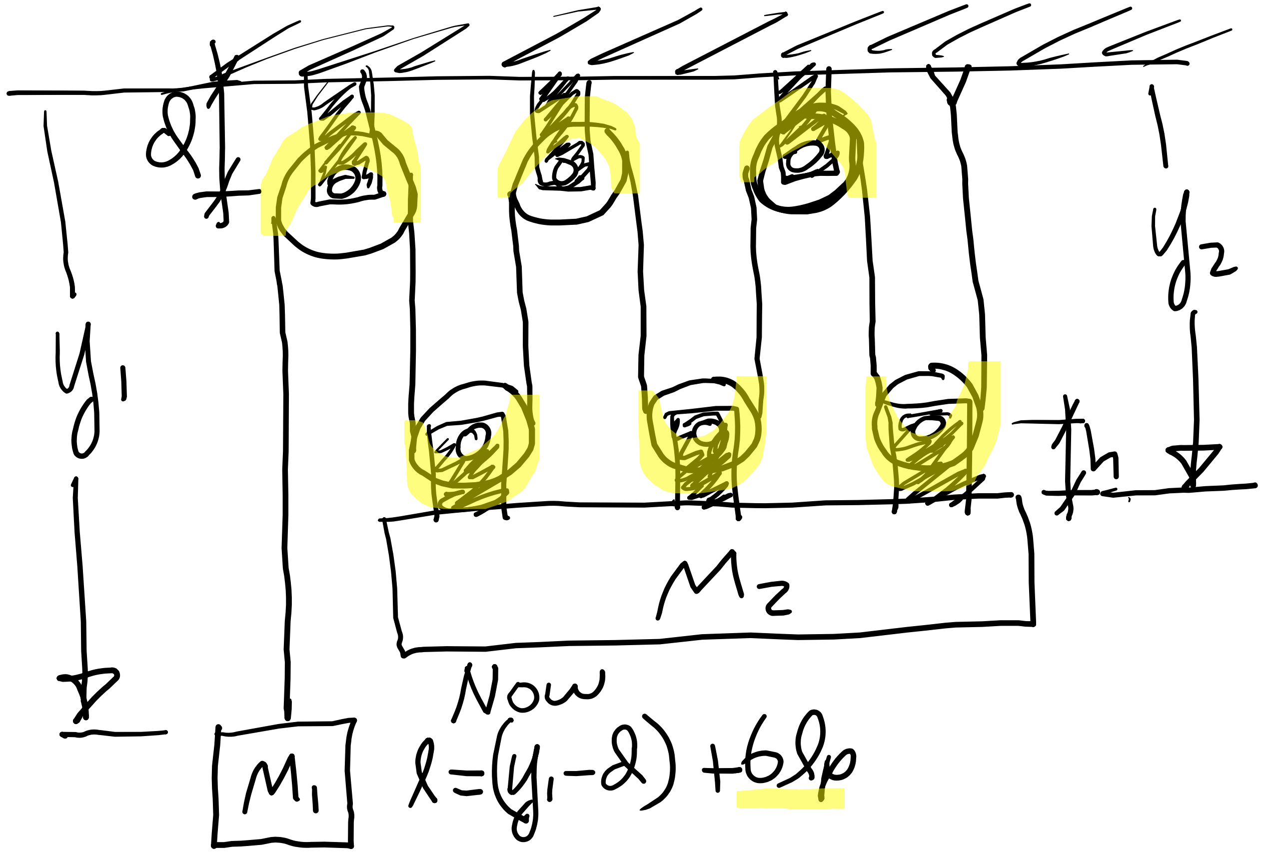
Another example



Now

$l = (y_1 - d)$

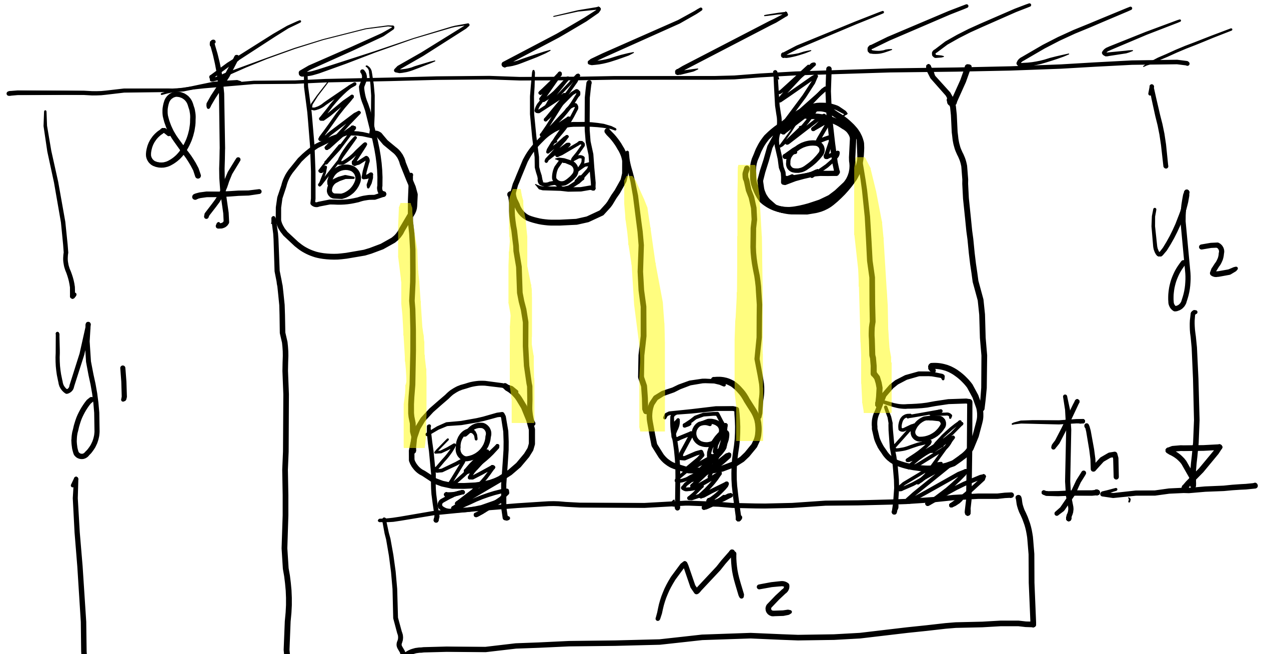
Another example



Now

$l = (y_1 - d) + 6 l_p$

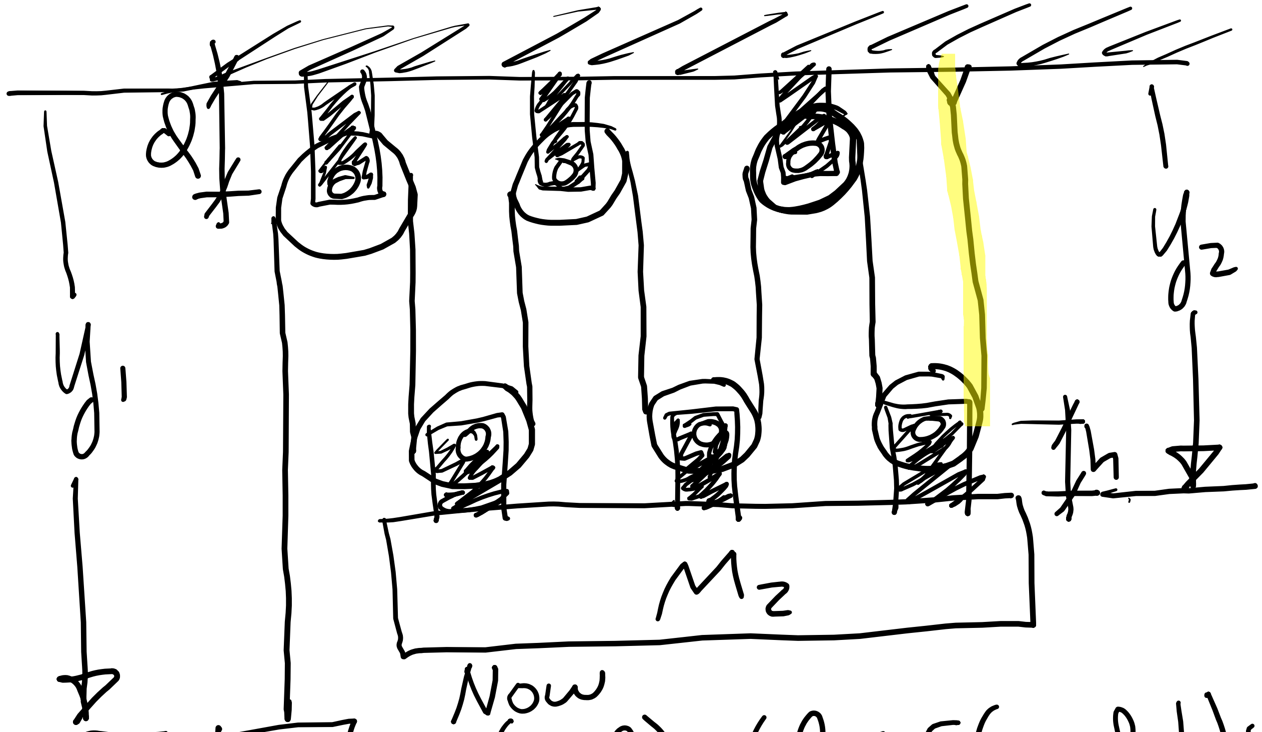
Another example



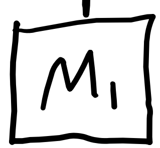
Now

M_1 $\quad l = (y_1 - d) + 6l_p + 5(y_2 - d - h)$

Another example

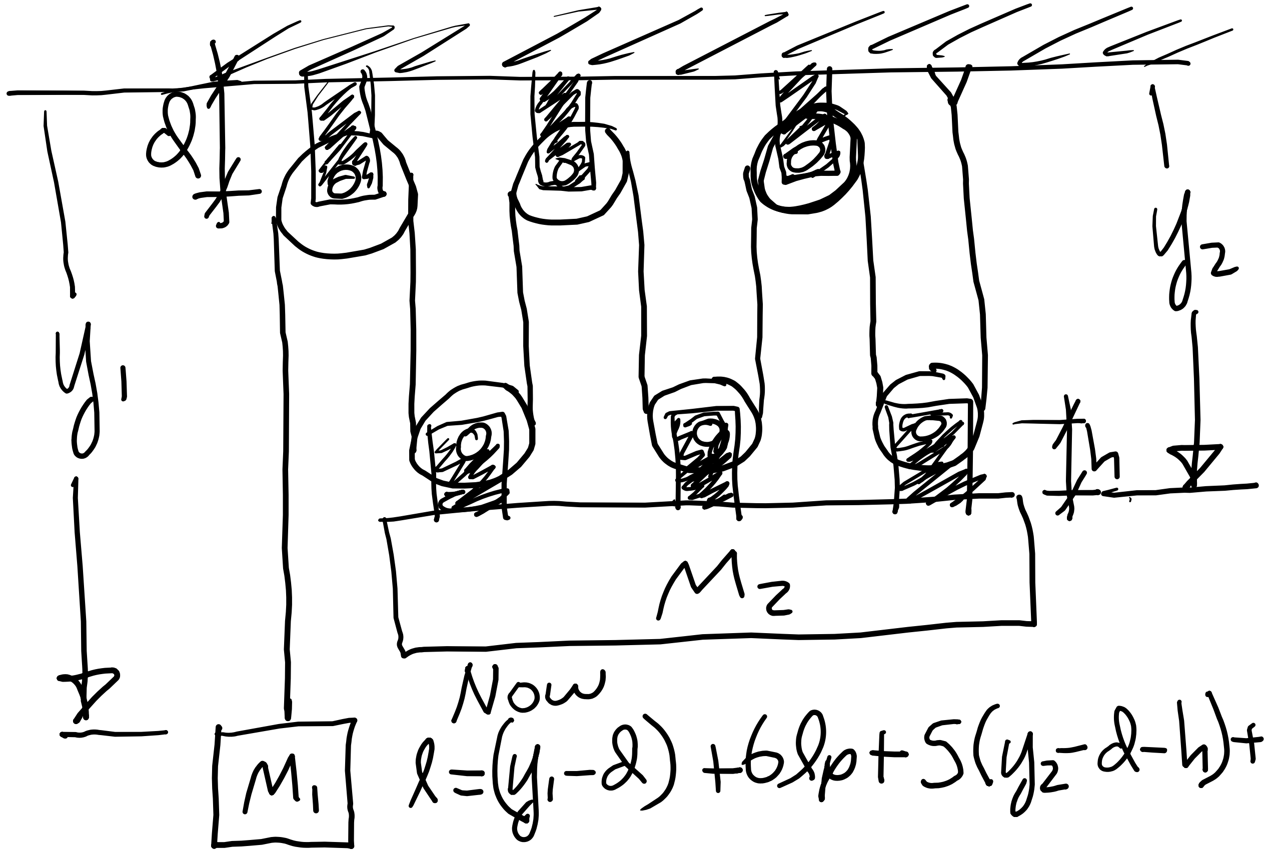


Now



$$l = (y_1 - d) + 6 l_p + 5(y_2 - d - h) + (y_2 - h)$$

Another example

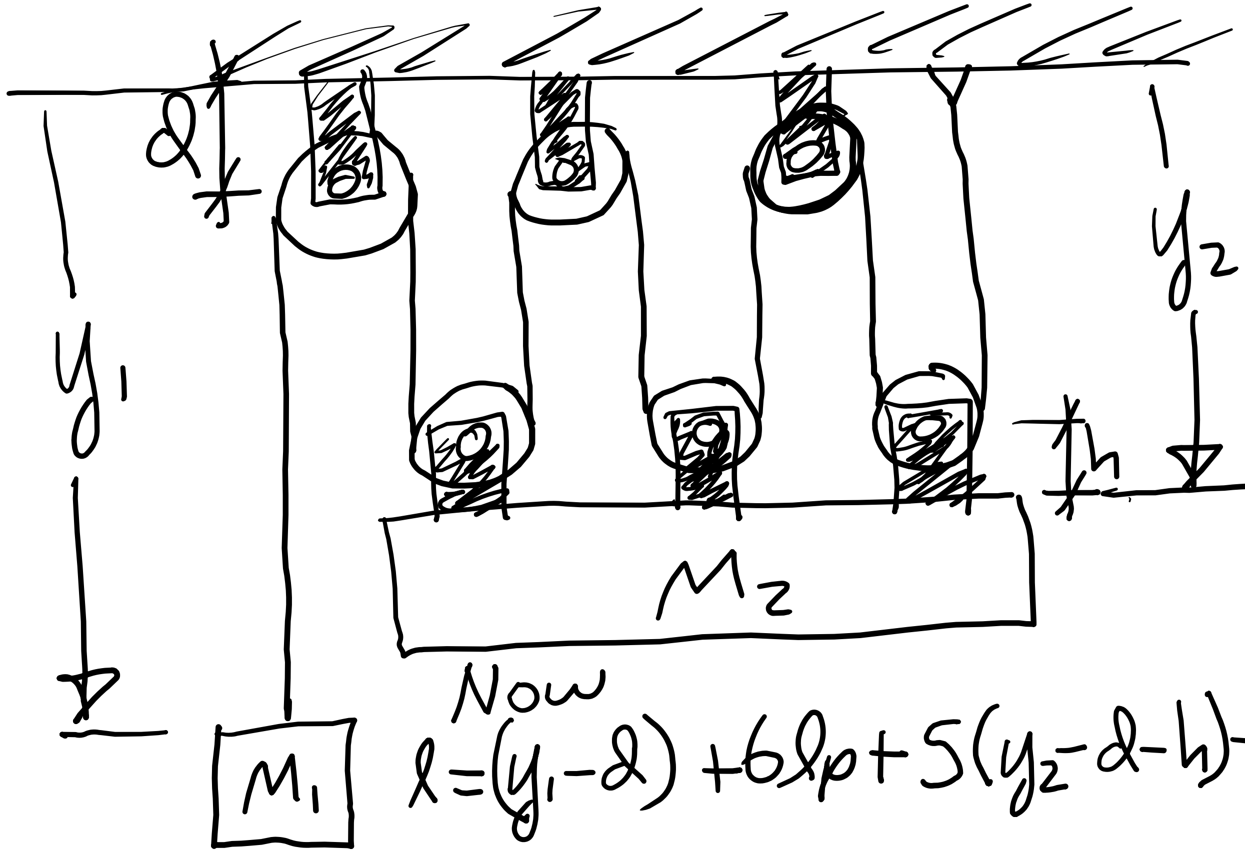


Now

$$l = (y_1 - d) + 6l_p + 5(y_2 - d - h) + (y_2 - h)$$

OR simply $\quad y_1 + 6y_2 = \text{const}$

Another example

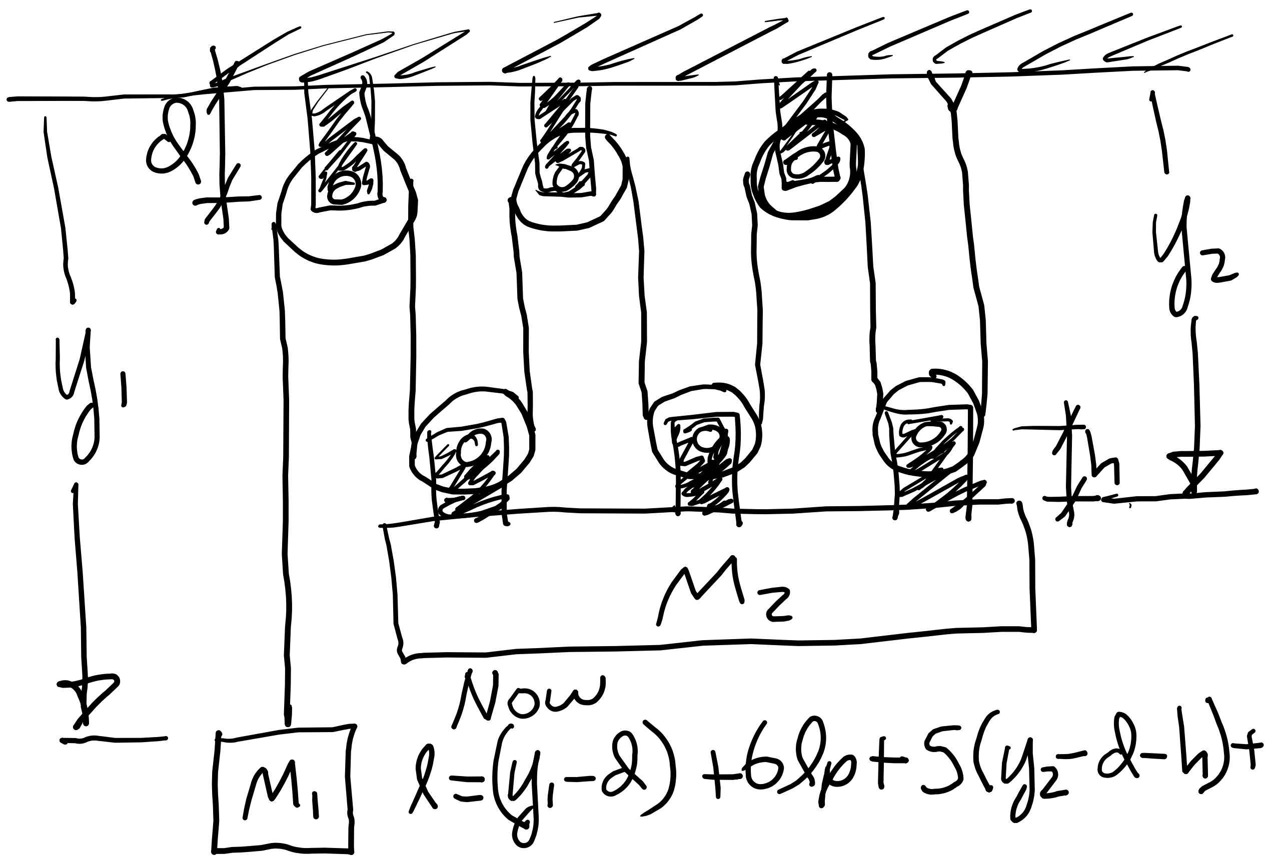


Now $l = (y_1 - d) + 6 l_p + 5(y_2 - d - h) + (y_2 - h)$

OR simply $y_1 + 6 y_2 = \text{const} \Rightarrow$

$v_1 + 6 v_2 = 0$

Another example



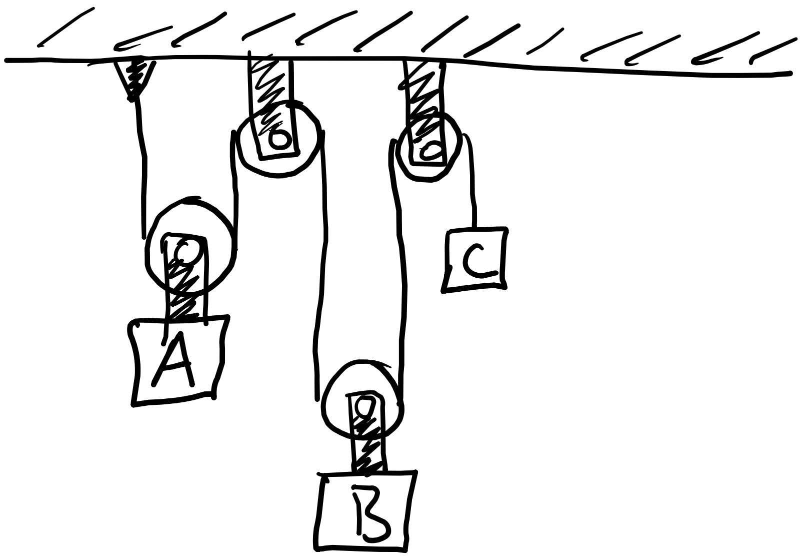
Now

$$l = (y_1 - d) + 6l_p + 5(y_2 - d - h) + (y_2 - h)$$

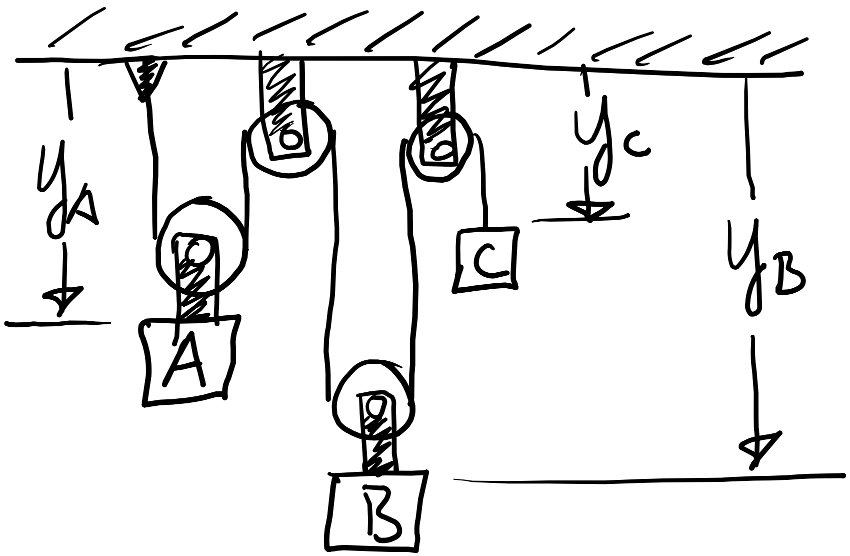
OR simply $y_1 + 6y_2 = \text{const} \Rightarrow$

$$V_1 + 6V_2 = 0 \Rightarrow V_2 = -\frac{V_1}{6}$$

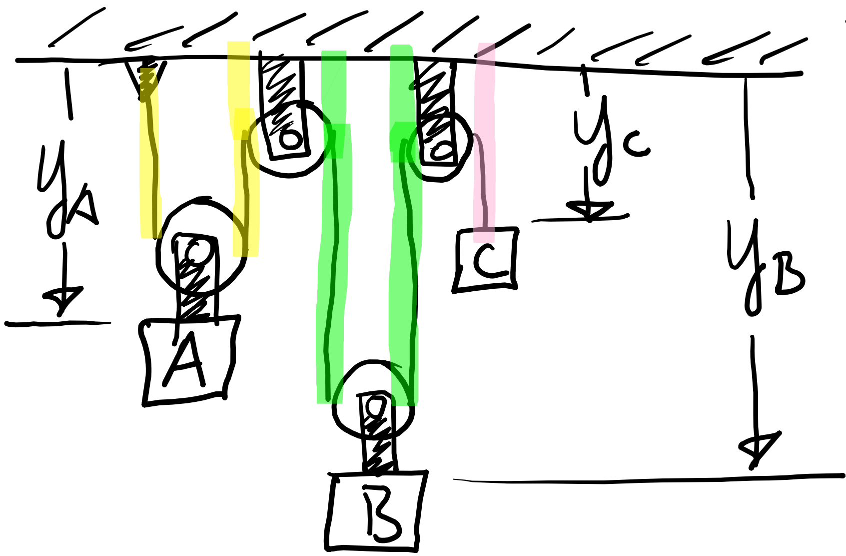
One more example



One more example



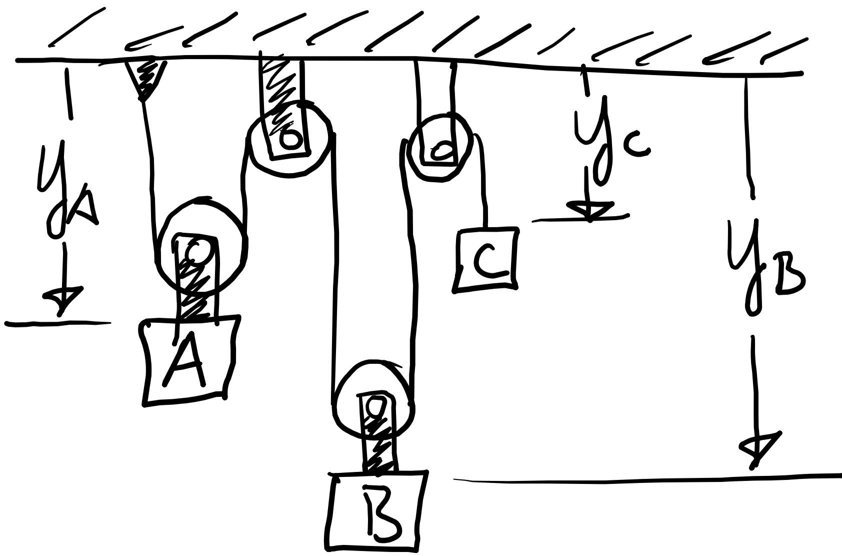
One more example



So

$$2y_A + 2y_B + y_C = \text{Const}$$

One more example

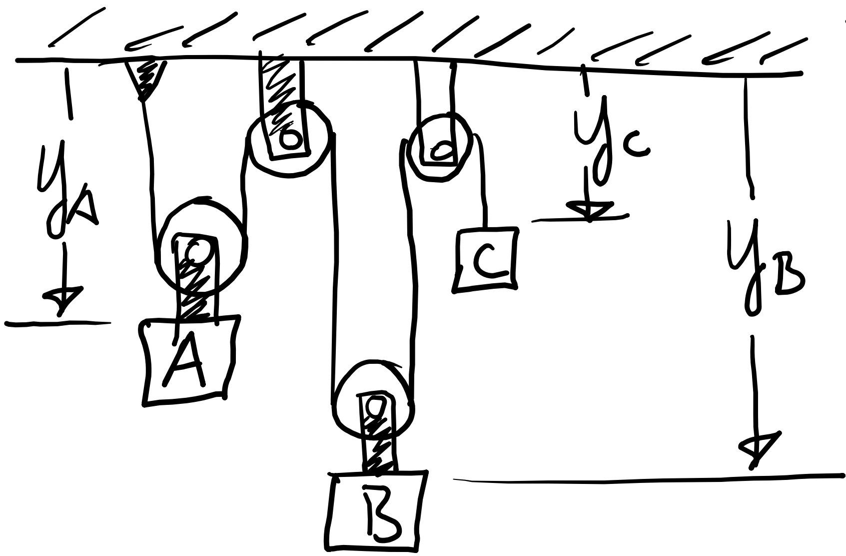


So

$$2y_A + 2y_B + y_C = \text{Const}$$

$$\Rightarrow 2v_A + 2v_B + v_C = 0$$

One more example



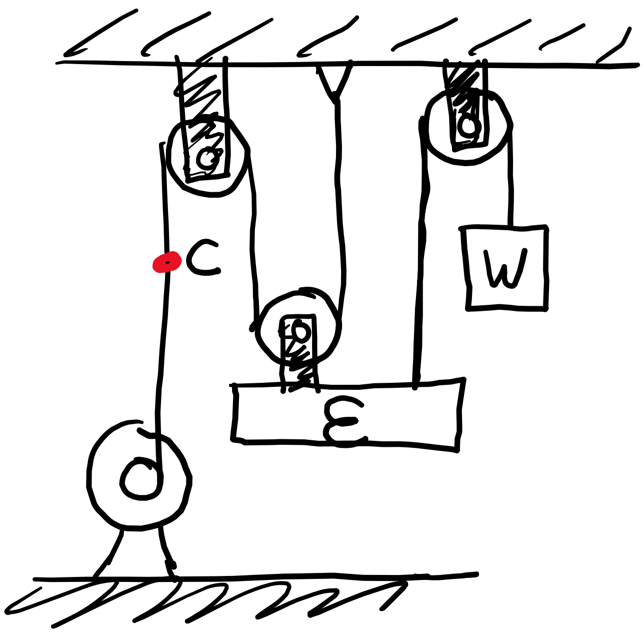
So

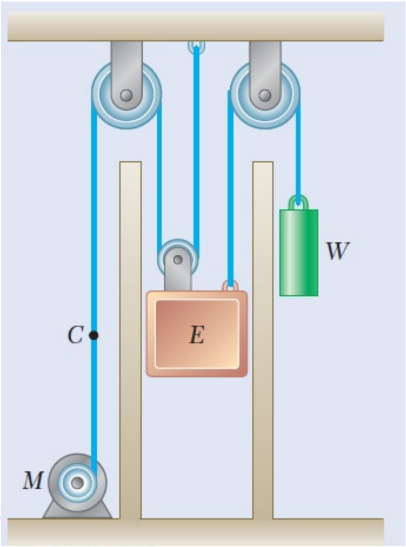
$$2y_A + 2y_B + y_C = \text{Const}$$

$$\Rightarrow 2v_A + 2v_B + v_C = 0$$

$$\& \quad 2a_A + 2a_B + a_C = 0$$

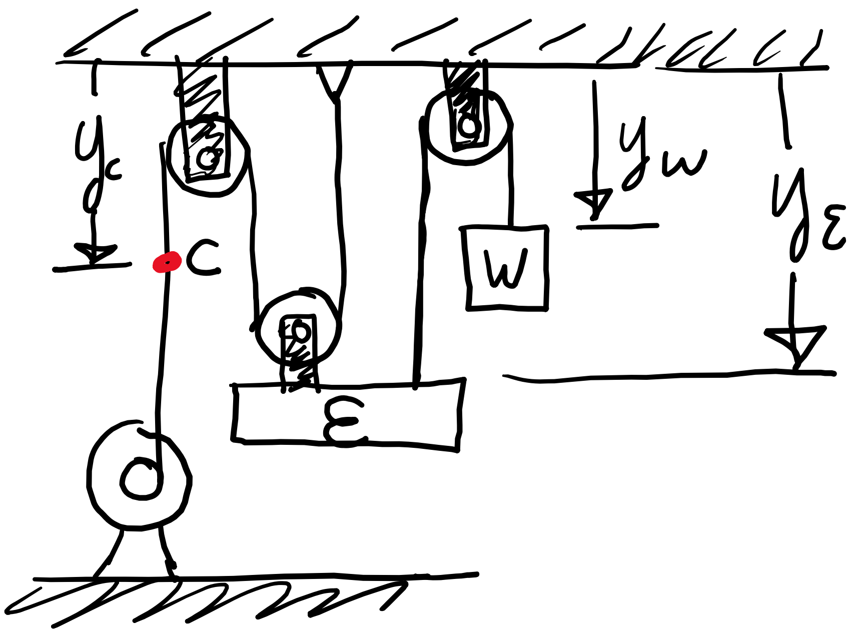
Notes on problems: $\boxed{11.47}$

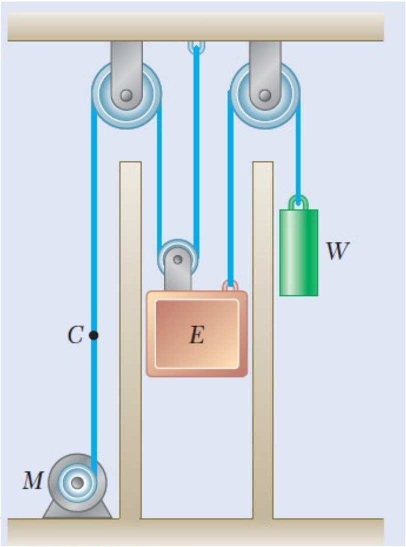




11.47 The elevator E shown in the figure moves downward with a constant velocity of 4 m/s. Determine (*a*) the velocity of the cable C, (*b*) the velocity of the counterweight W, (*c*) the relative velocity of the cable C with respect to the elevator, (*d*) the relative velocity of the counterweight W with respect to the elevator.

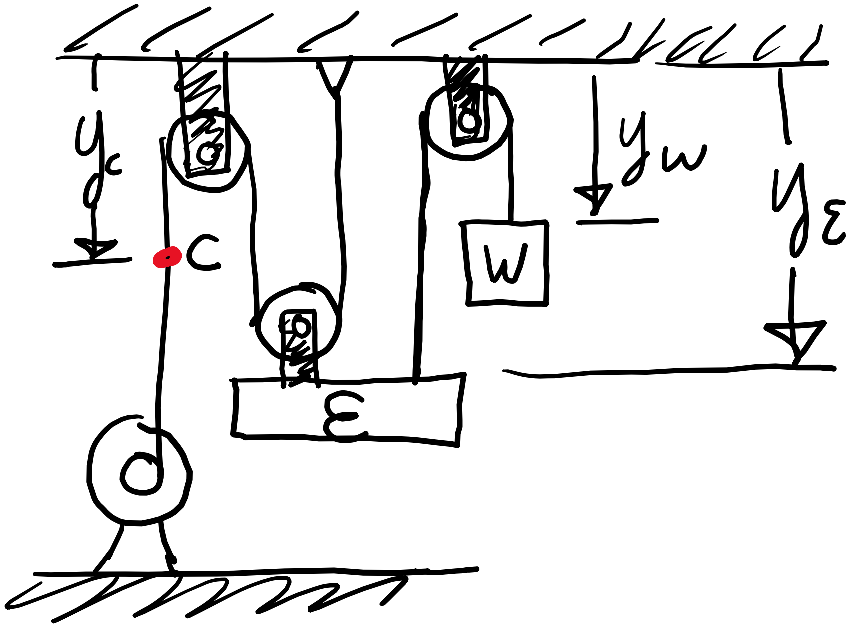
Notes on problems: $\boxed{11.47}$



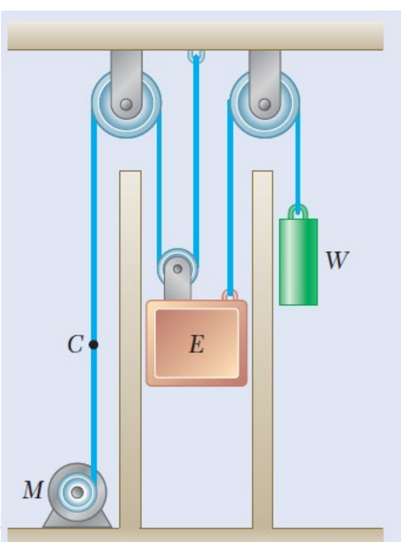


11.47 The elevator E shown in the figure moves downward with a constant velocity of 4 m/s. Determine (*a*) the velocity of the cable C, (*b*) the velocity of the counterweight W, (*c*) the relative velocity of the cable C with respect to the elevator, (*d*) the relative velocity of the counterweight W with respect to the elevator.

Notes on problems: $\boxed{11.47}$

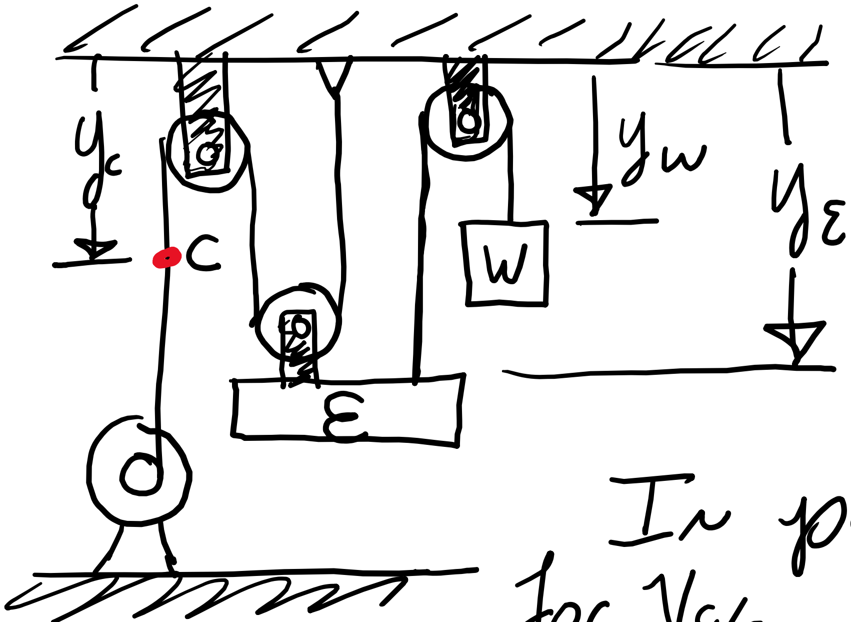


Notice the <u>two</u> ropes $\Rightarrow$ two equations



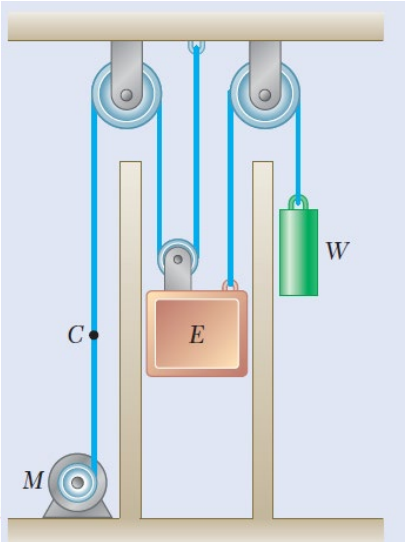
11.47 The elevator E shown in the figure moves downward with a constant velocity of 4 m/s. Determine (*a*) the velocity of the cable C, (*b*) the velocity of the counterweight W, (*c*) the relative velocity of the cable C with respect to the elevator, (*d*) the relative velocity of the counterweight W with respect to the elevator.

Notes on problems: $\boxed{11.47}$



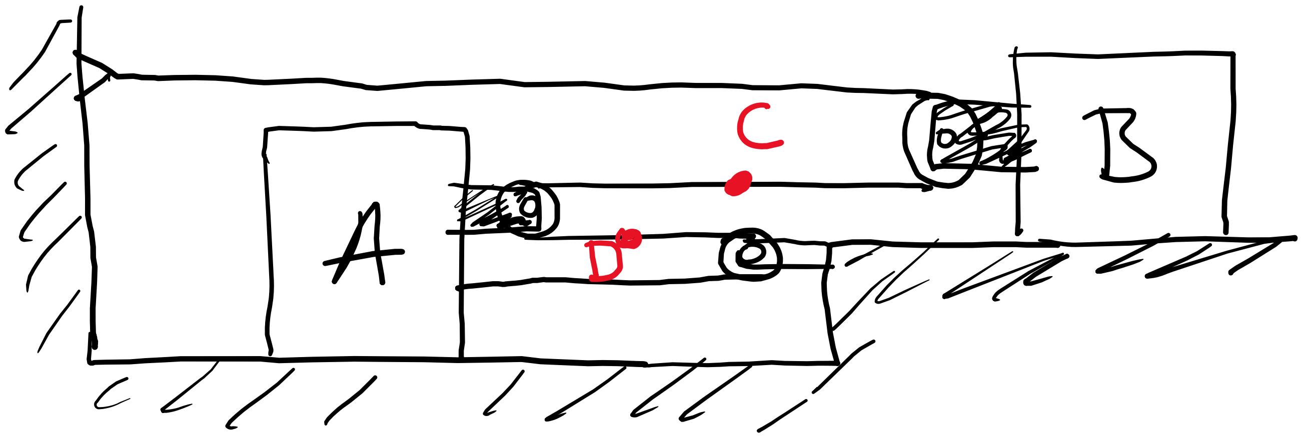
Notice the two ropes ⇒ two equations

In part (c) you are asked for $V_{C/E}$. Make sure to include direction in calculation!!



11.47 The elevator E shown in the figure moves downward with a constant velocity of 4 m/s. Determine (*a*) the velocity of the cable C, (*b*) the velocity of the counterweight W, (*c*) the relative velocity of the cable C with respect to the elevator, (*d*) the relative velocity of the counterweight W with respect to the elevator.

Notes on problem $\boxed{11.51}$



Given

$v_B = 300 \frac{mm}{s}$

11.51 Slider block B moves to the right with a constant velocity of 300 mm/s. Determine (*a*) the velocity of slider block A, (*b*) the velocity of portion C of the cable, (*c*) the velocity of portion D of the cable, (*d*) the relative velocity of portion C of the cable with respect to slider block A.

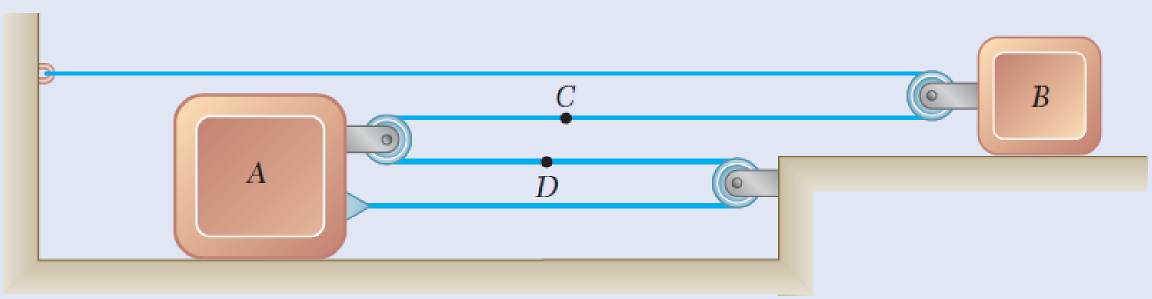
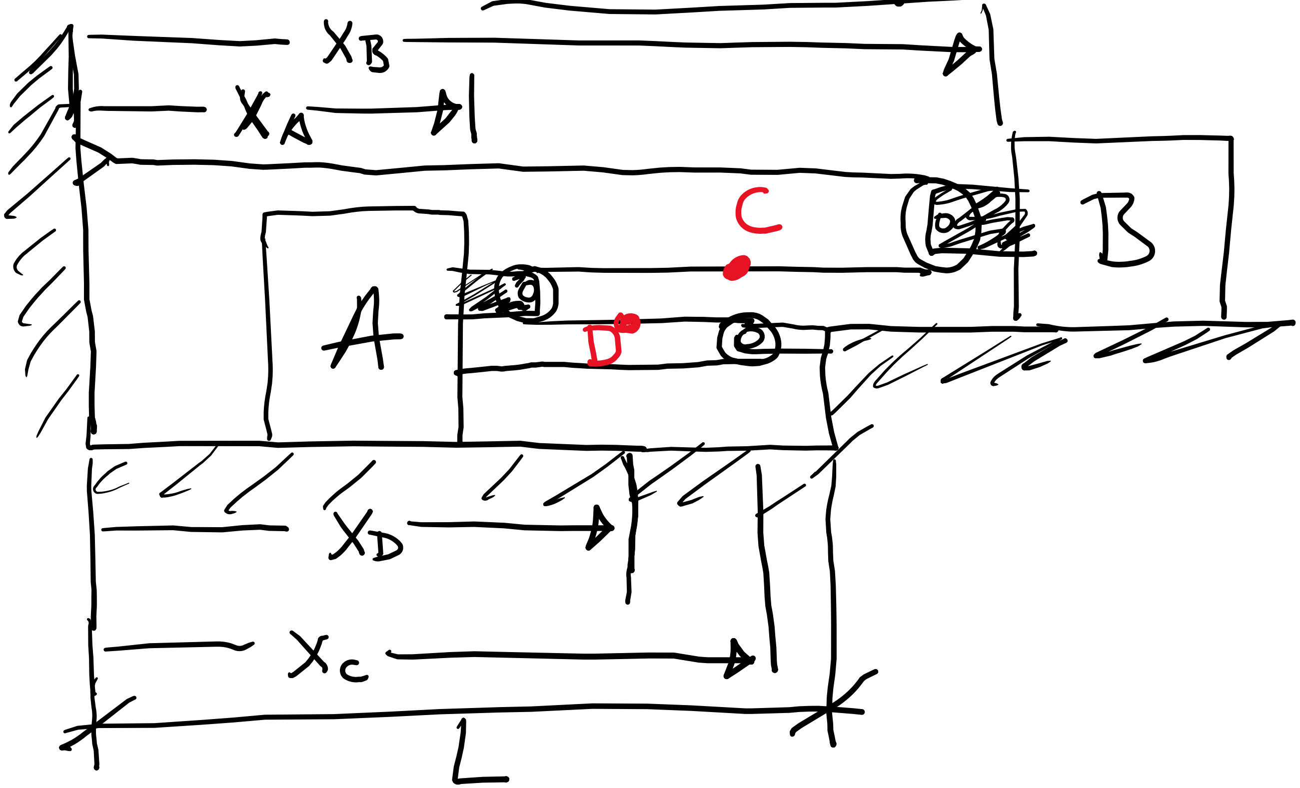


Fig. P11.51 and P11.52

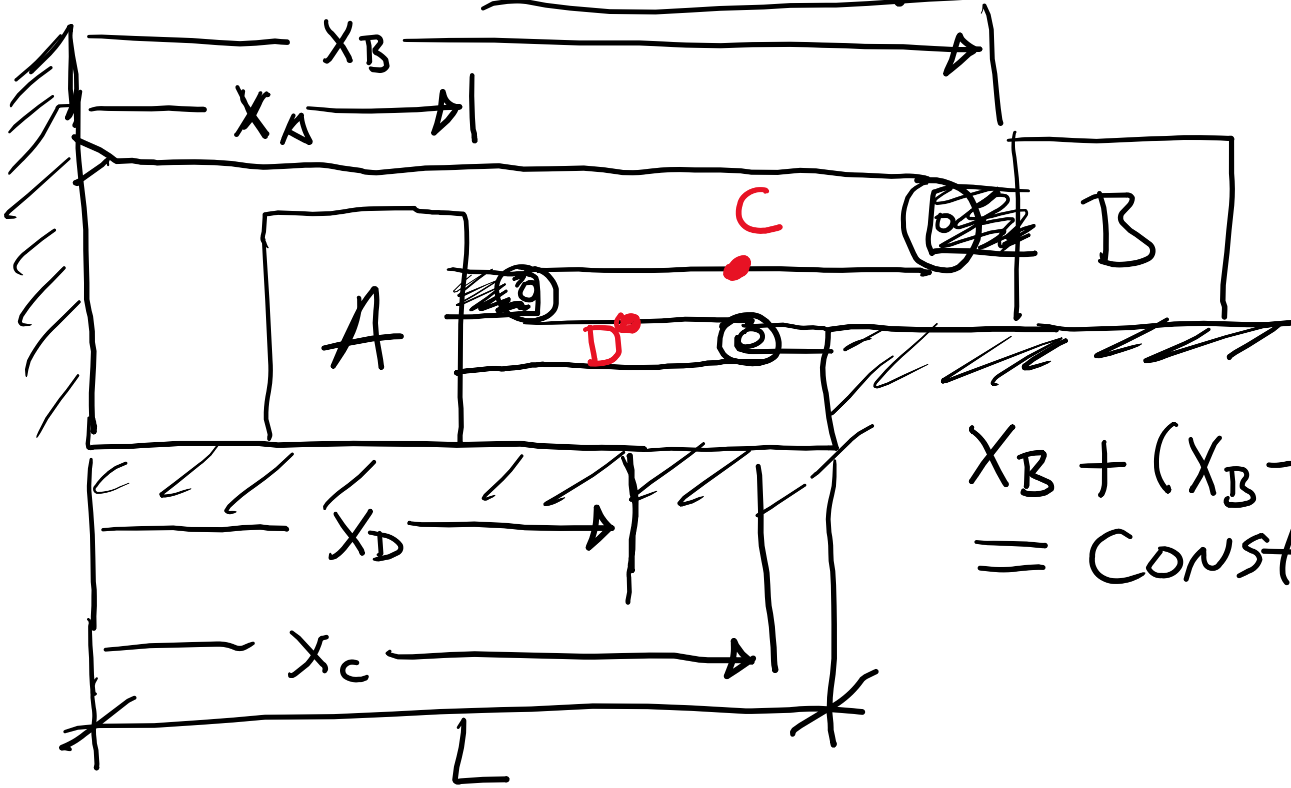
Notes on problem $\boxed{11.51}$



Given

$v_B = 300 \frac{mm}{s}$

Notes on problem $\boxed{11.51}$



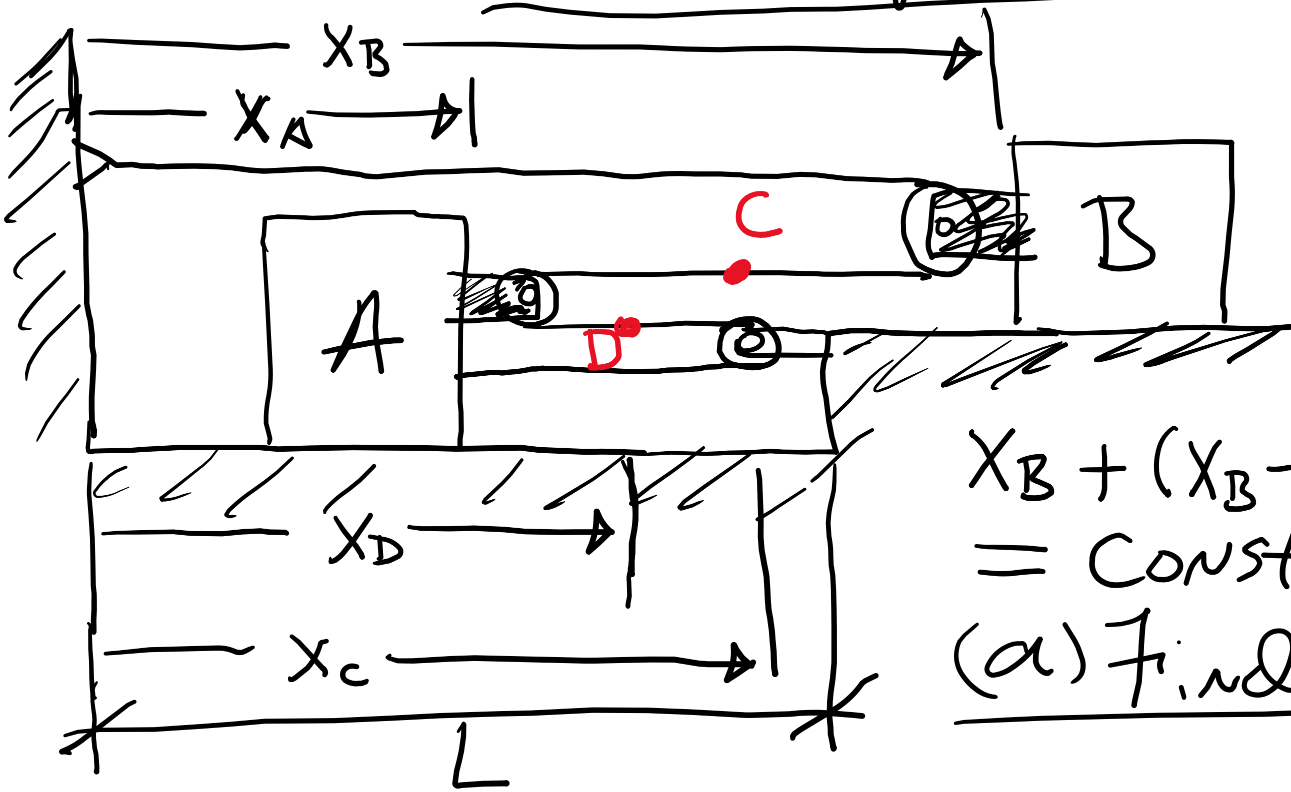
Given

$v_B = 300 \frac{mm}{s}$

$X_B + (X_B - X_A) + (L - X_A)2$

$=$ constant.

Notes on problem $\boxed{11.51}$



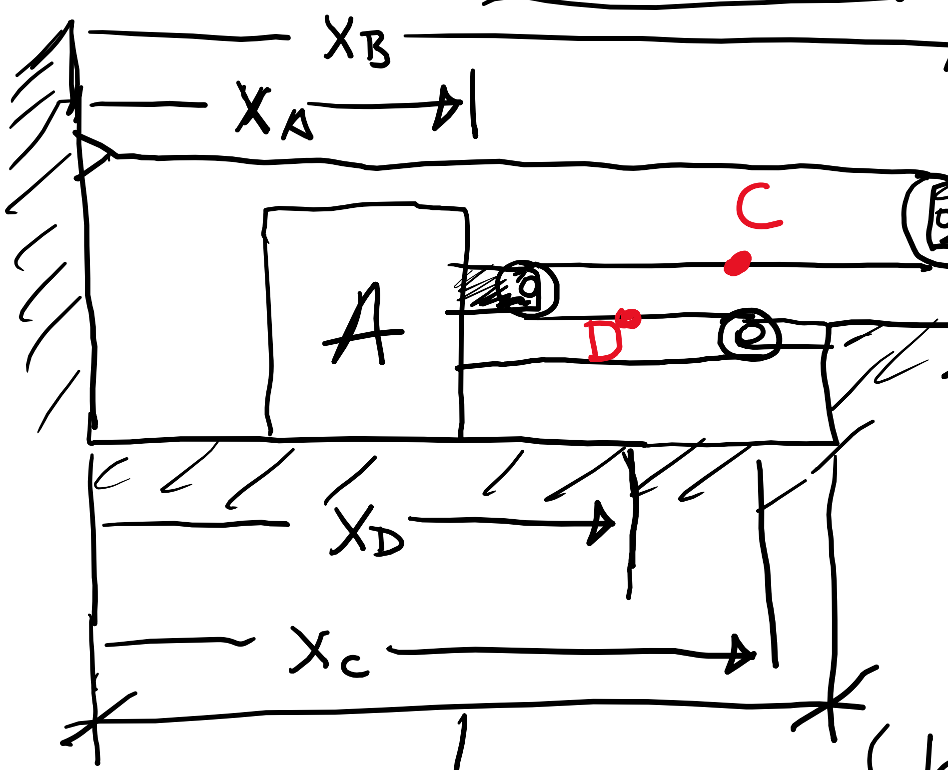
Given

$v_B = 300 \frac{mm}{s}$

$x_B + (x_B - x_A) + (L - x_A)2$
$= \text{constant}$

(a) Find v_A: just take derivitives.

Notes on problem $\boxed{11.51}$



Given
$v_B = 300 \frac{mm}{s}$

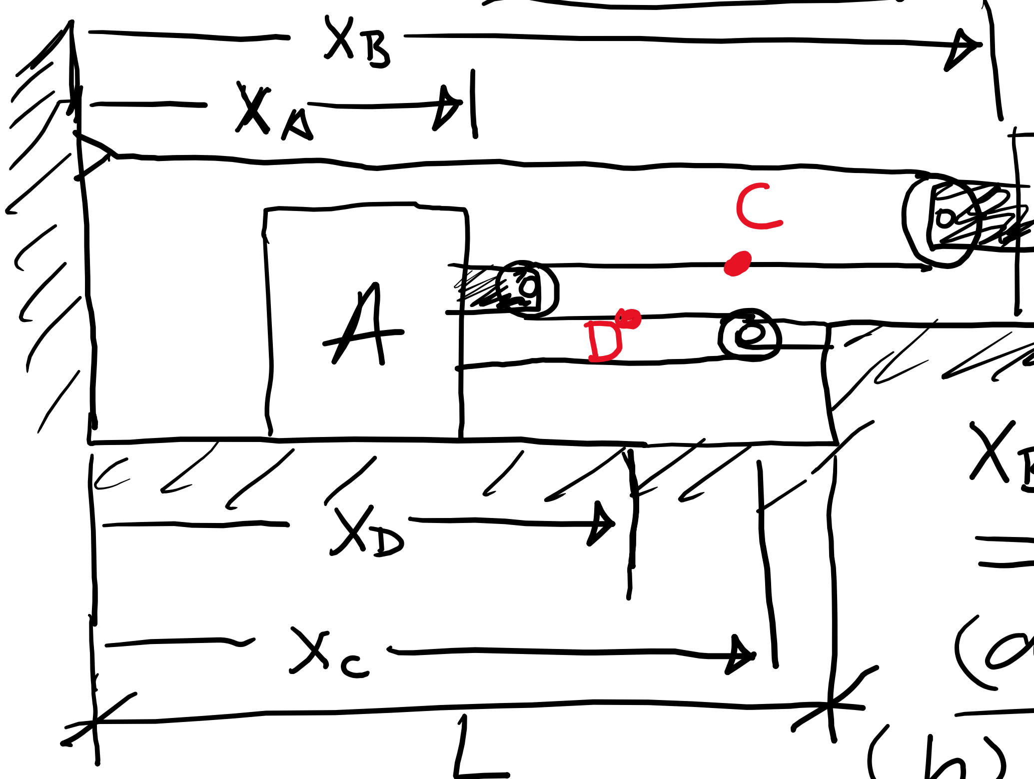
$X_B + (X_B - X_A) + (L - X_A)2 = \text{constant}$

(a) Find V_A: just take derivitives.

(b) Find V_C
(c) Find V_D

follow rope from one end to point of interest.

Notes on problem $\boxed{11.51}$



Given

$v_B = 300 \frac{mm}{s}$

(a)

$X_B + (X_B - X_A) + (L - X_A)2 = \text{constant}$

(a) find v_A: just take derivitives.

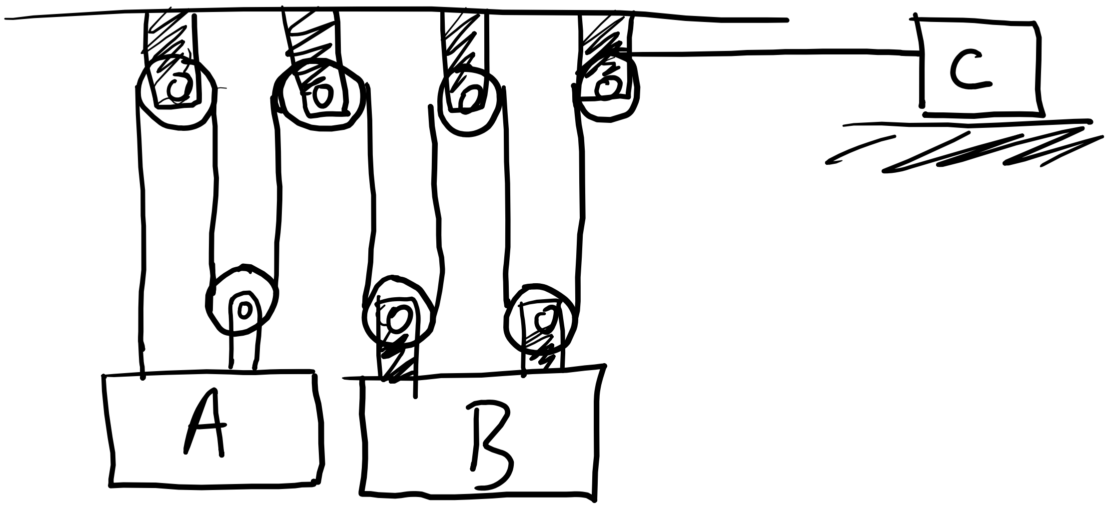
(b) find v_C

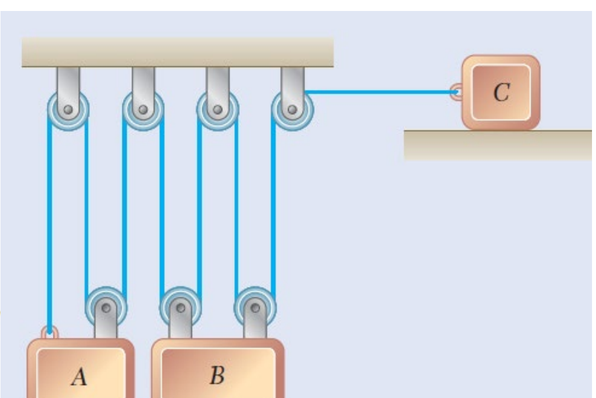
(c) find v_D

} follow rope from one end to point of interest.

(d) find $v_{C/A}$: Make sure to note direction

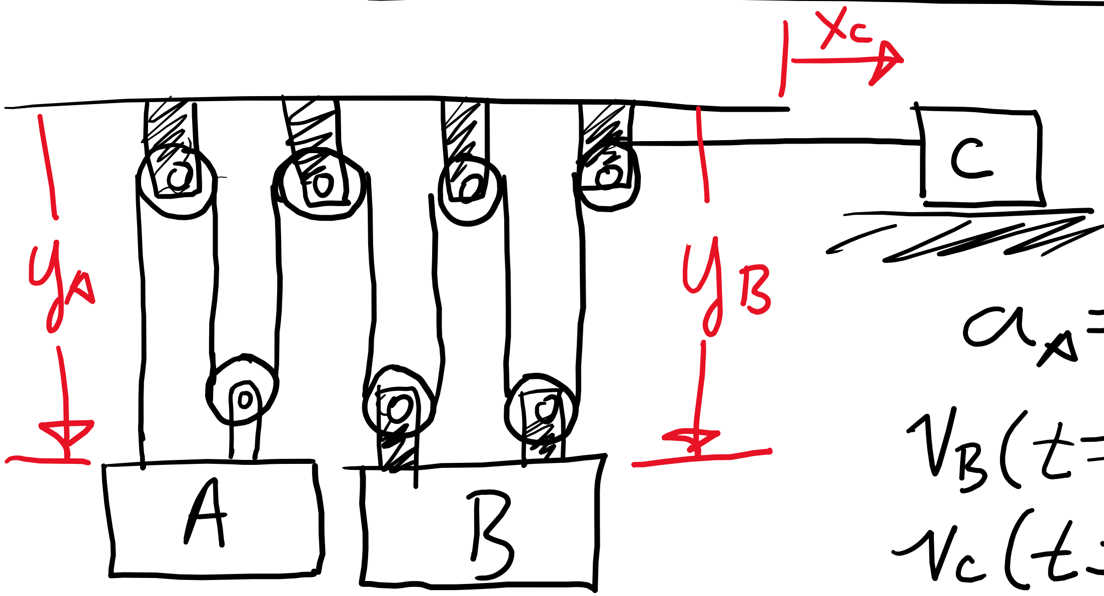
Notes on problem $\boxed{11.57}$





11.57 Block *B* starts from rest, block *A* moves with a constant acceleration, and slider block *C* moves to the right with a constant acceleration of 75 mm/s^2. Knowing that at $t = 2$ s the velocities of *B* and *C* are 480 mm/s downward and 280 mm/s to the right, respectively, determine (*a*) the accelerations of *A* and *B*, (*b*) the initial velocities of *A* and *C*, (*c*) the change in position of slider block *C* after 3 s.

Notes on problem $\boxed{11.57}$

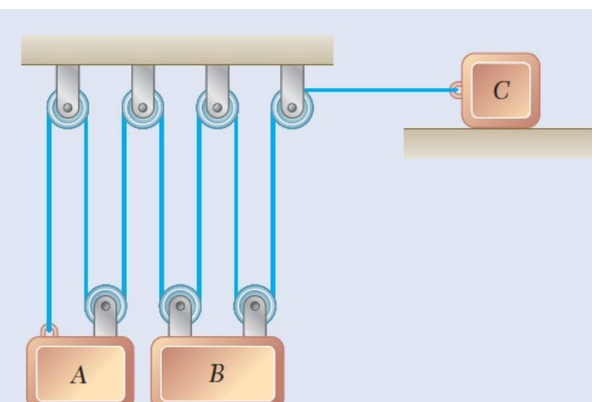


Given: $v_{0B} = 0$

$a_A = \text{const.}, \quad a_c = 75\frac{mm}{s^2}$

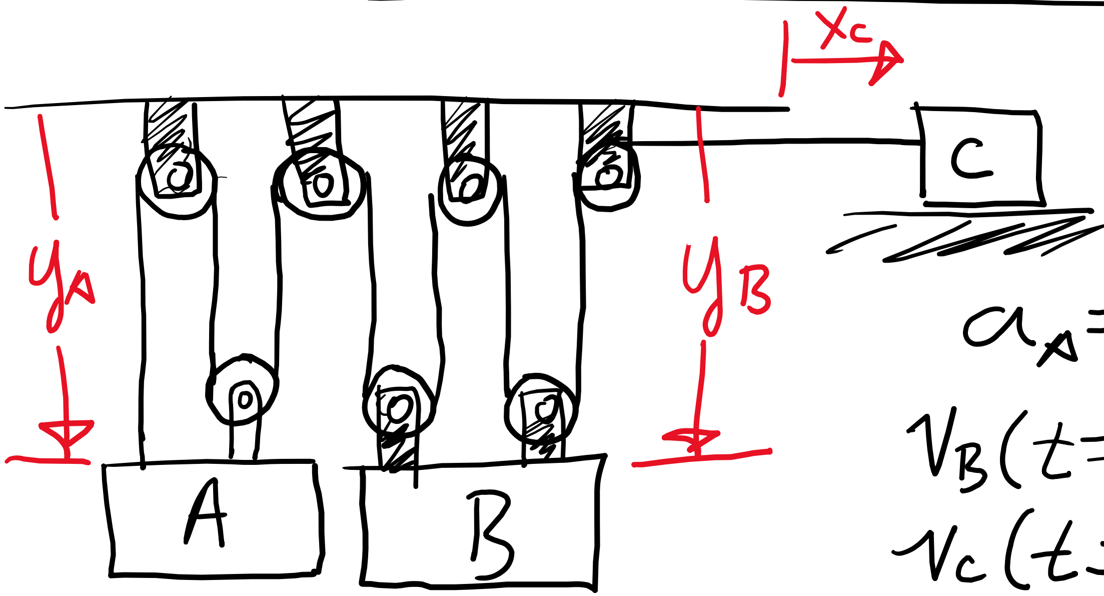
$v_B(t=2s) = 480\frac{mm}{s}$

$v_c(t=2s) = 280\frac{mm}{s}$



11.57 Block *B* starts from rest, block *A* moves with a constant acceleration, and slider block *C* moves to the right with a constant acceleration of 75 mm/s^2. Knowing that at $t = 2$ s the velocities of *B* and *C* are 480 mm/s downward and 280 mm/s to the right, respectively, determine (*a*) the accelerations of *A* and *B*, (*b*) the initial velocities of *A* and *C*, (*c*) the change in position of slider block *C* after 3 s.

Notes on problem $\boxed{11.57}$



Given: $v_{0B} = 0$

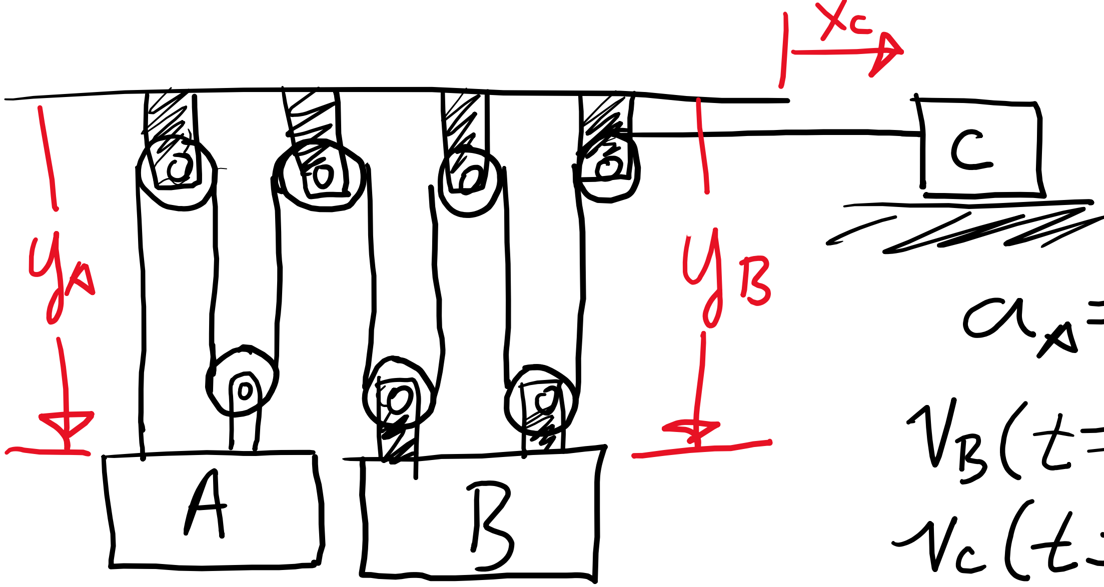
$a_A = \text{const.}$, $a_C = 75\,\frac{mm}{s^2}$

$v_B(t=2s) = 480\,\frac{mm}{s}$

$v_C(t=2s) = 280\,\frac{mm}{s}$

(a) Find a_A & a_B : Get equation relating y_A, y_B & x_C, then v_A, v_B & v_C

Notes on problem $\boxed{11.57}$



Given: $v_{0B} = 0$

$a_A = \text{const.}$, $a_C = 75 \frac{mm}{s^2}$

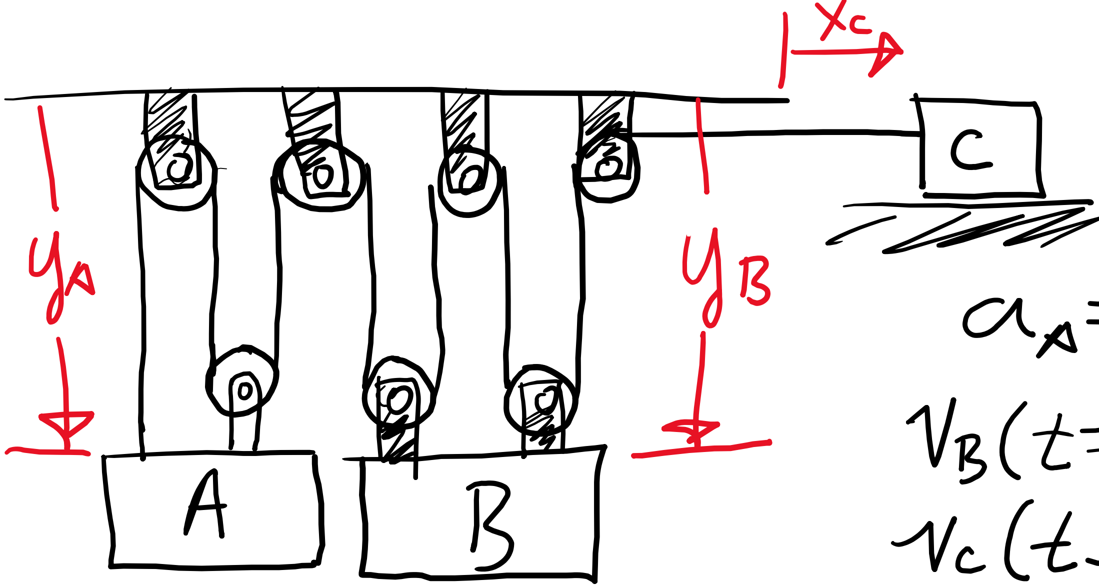
$v_B(t=2s) = 480 \frac{mm}{s}$

$v_C(t=2s) = 280 \frac{mm}{s}$

(a) Find a_A & a_B : Get equation relating y_A, y_B & x_C, then v_A, v_B & v_C

Note: $a_A = \text{const.}$ & $a_C = \text{const} \Rightarrow a_B = \text{const.}$

Notes on problem $\boxed{11.57}$



Given: $v_{0B} = 0$

$a_A = \text{const.}$, $a_C = 75\,\frac{mm}{s^2}$

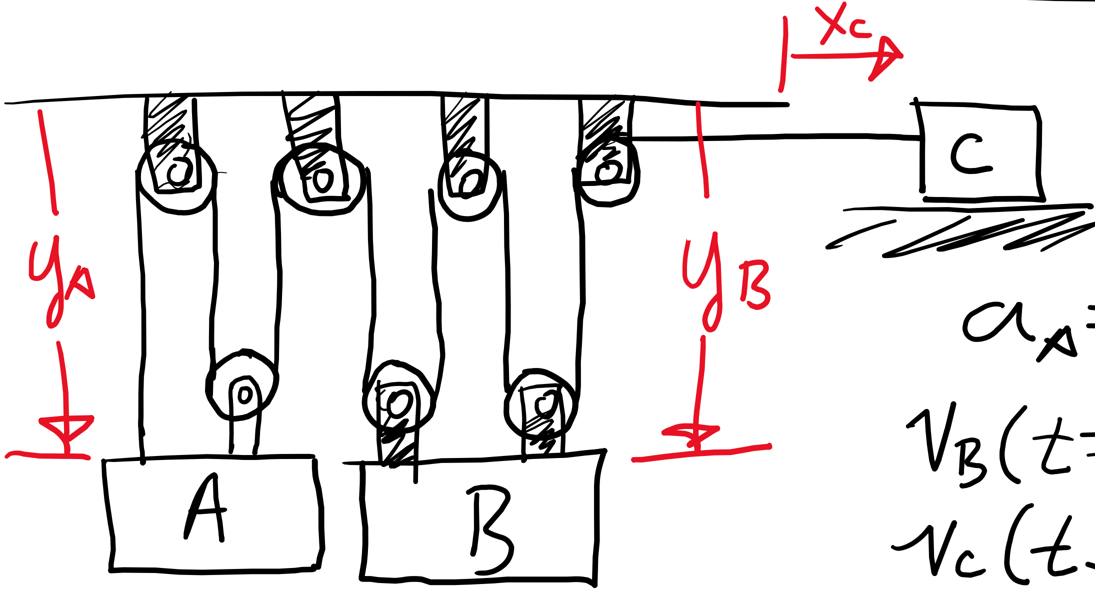
$v_B(t=2s) = 480\,\frac{mm}{s}$

$v_C(t=2s) = 280\,\frac{mm}{s}$

(a) Find a_A & a_B : Get equation relating y_A, y_B & x_C, then v_A, v_B & v_C

Note: $a_A = \text{const.}$ & $a_C = \text{const} \Rightarrow a_B = \text{const.}$ & since $v_{B0} = 0$ then $v_B = a_B t$

Notes on problem $\boxed{11.57}$



Given: $v_{0B} = 0$

$a_A = \text{const.}$, $a_C = 75 \frac{mm}{s^2}$

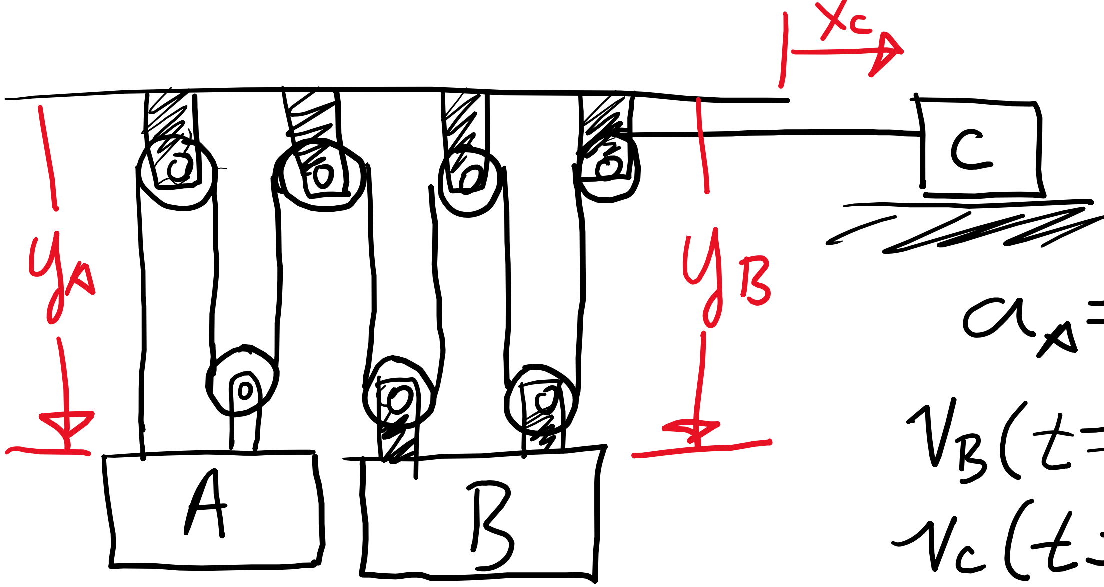
$v_B(t=2s) = 480 \frac{mm}{s}$

$v_C(t=2s) = 280 \frac{mm}{s}$

(a) Find a_A & a_B : Get equation relating y_A, y_B & x_C, then v_A, v_B & v_C

Note: $a_A = \text{const.}$ & $a_C = \text{const} \Rightarrow a_B = \text{const.}$ & since $v_{B0} = 0$ then $v_B = a_B t$. $v_B(t=2s)$ is given. Use system of equations to get a_A & a_B

Notes on problem $\boxed{11.57}$



Given: $v_{0B} = 0$

$a_A = \text{const.}$, $a_C = 75 \frac{mm}{s^2}$

$v_B(t=2s) = 480 \frac{mm}{s}$

$v_C(t=2s) = 280 \frac{mm}{s}$

(a) Find a_A & a_B : Get equation relating y_A, y_B & x_C, then v_A, v_B & v_C

Note: $a_A = \text{const.}$ & $a_C = \text{const} \Rightarrow a_B = \text{const.}$ & since $v_{B0} = 0$ then $v_B = a_B t$. $v_B(t=2s)$ is given. Use system of equations to get a_A & a_B. For rest: Kinematics & system of equations