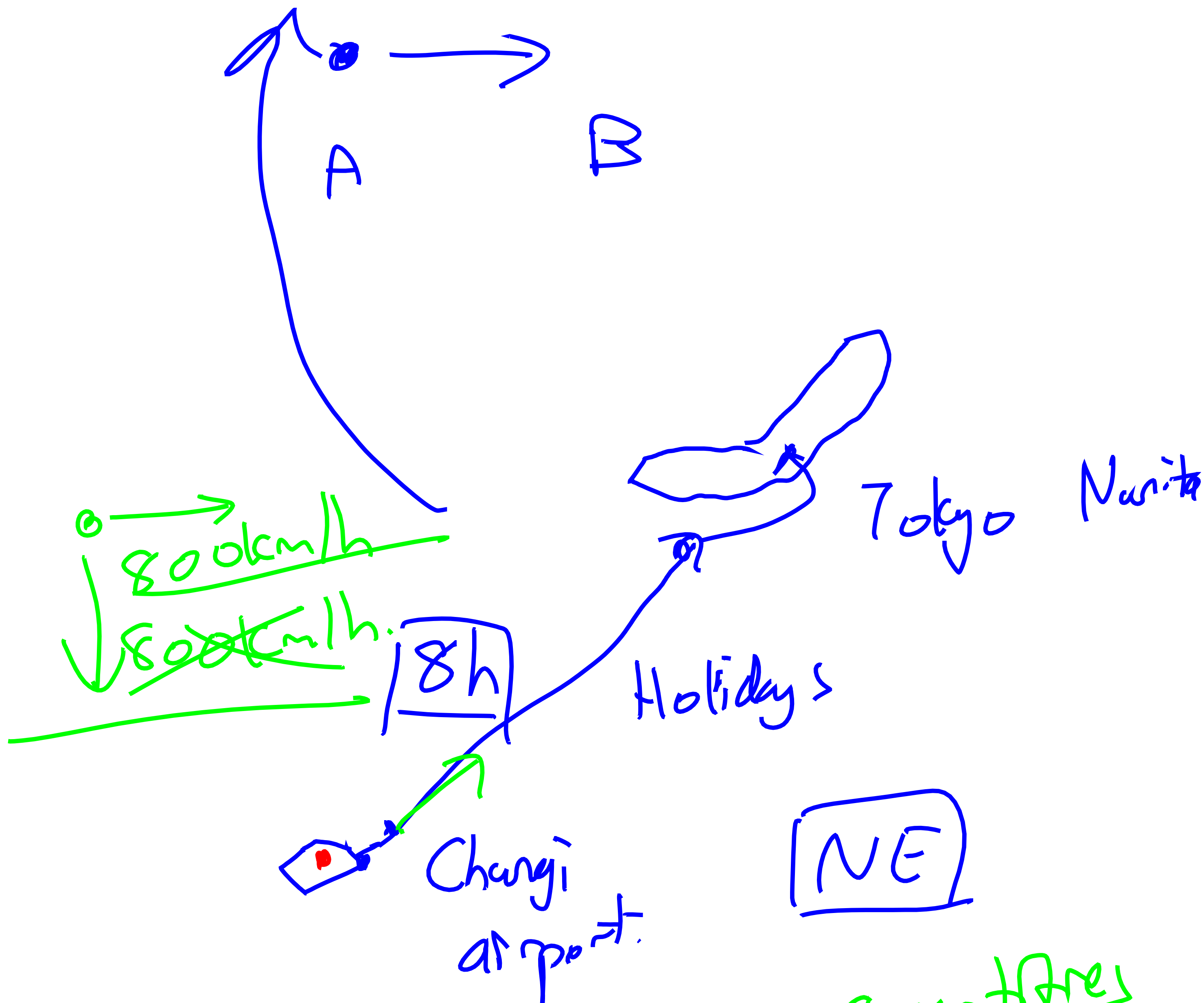
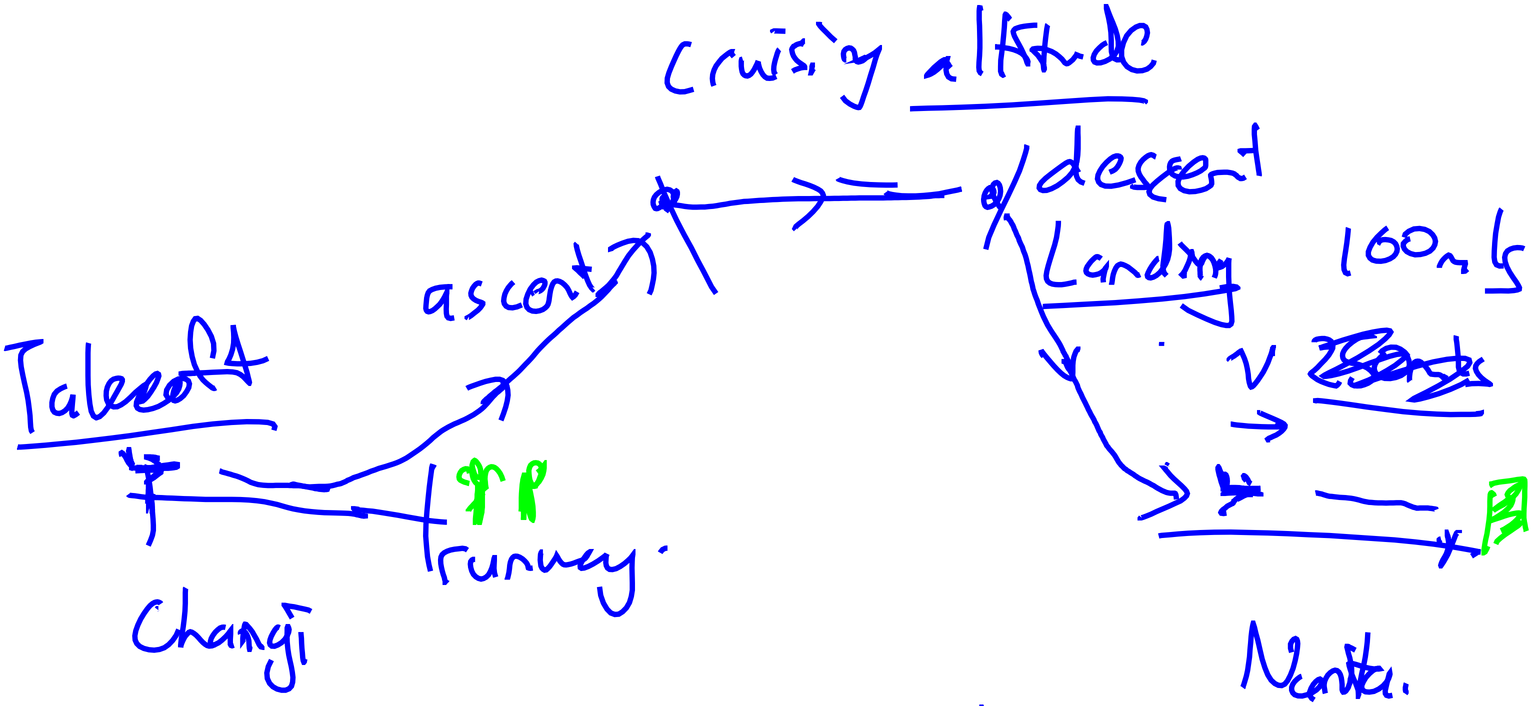
Kinematics



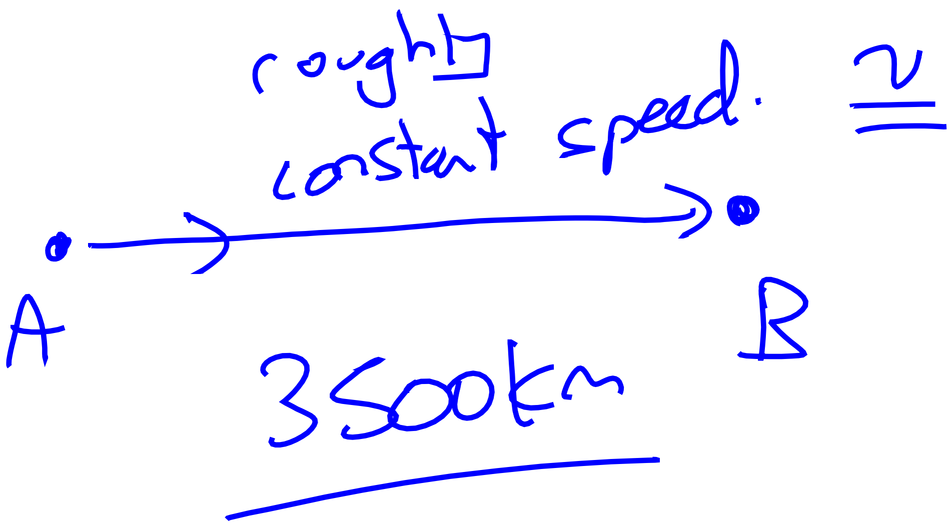
quantities

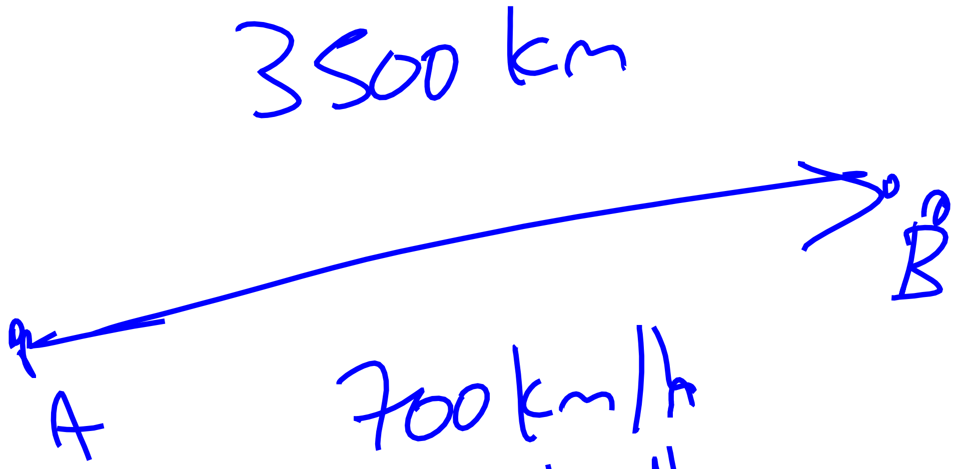
Vectors = Quantities w/ magnitude & direction.



How long does your runway need to be?

Cruising





700 km/h

−800 km/h

displacement.

$$S = v t$$

velocity.

$$v = \frac{\text{distance}}{\text{time}}$$

$$\text{time} = \frac{\text{distance}}{v}$$

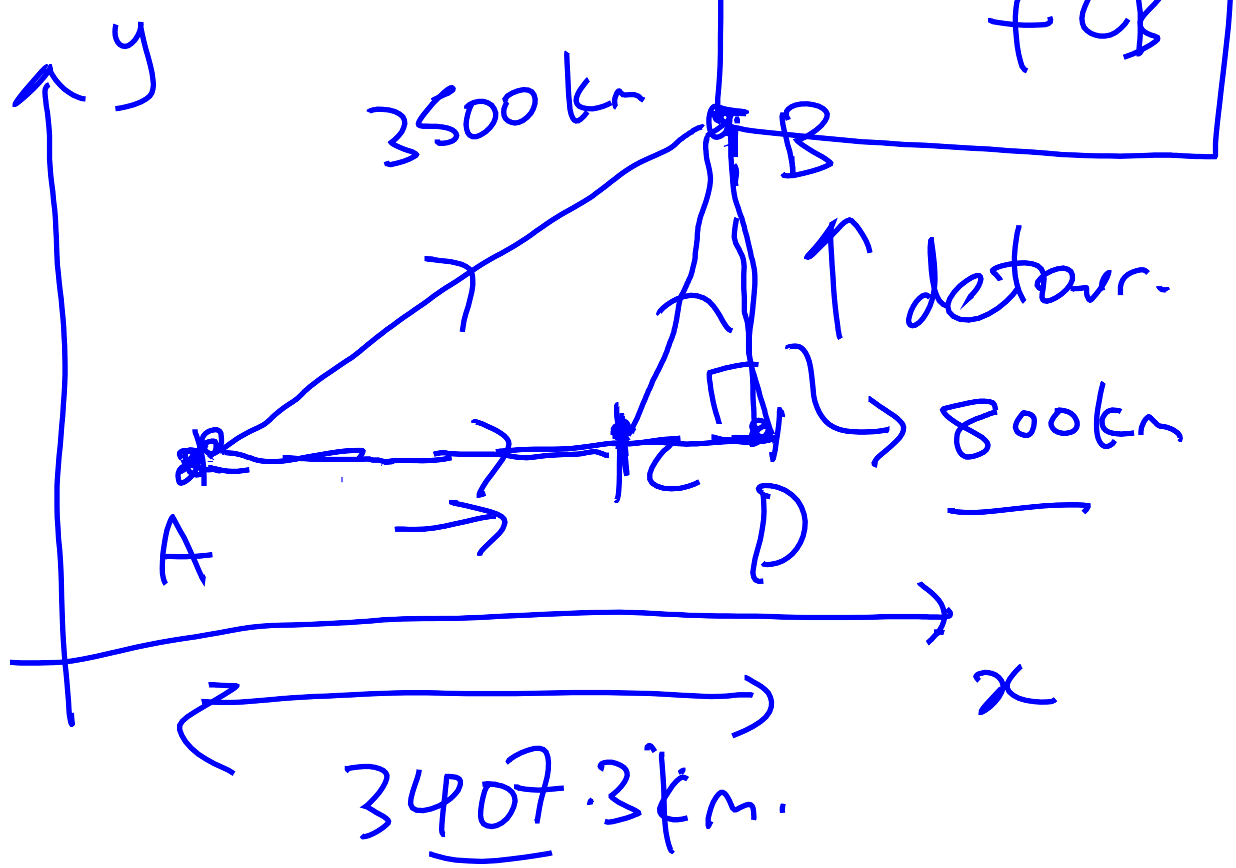
$$= \frac{3500\,(\text{km})}{700\,(\text{km/h})} = 5\,\text{h}$$

cruising alt

detour.

Direction becomes impt.

$$\vec{AB} = \vec{AC} + \vec{CB}$$



$$AD = \sqrt{3300^2 - 800^2}$$

$$= \underline{3407.3 km}$$

5sf.

$$AC = 3000 km.$$

$$BC^2 = \sqrt{407.3^2 + 800^2}$$

$$BC(km) = \sqrt{805,929}) km.$$

$$= 897.7 km.$$

$A\overset{C}{\cancel{B}} + BC$

$= 3000\,\text{km} + 897.7\,\text{km}.$

$= 3897.7\ \text{km}$

extra time taken

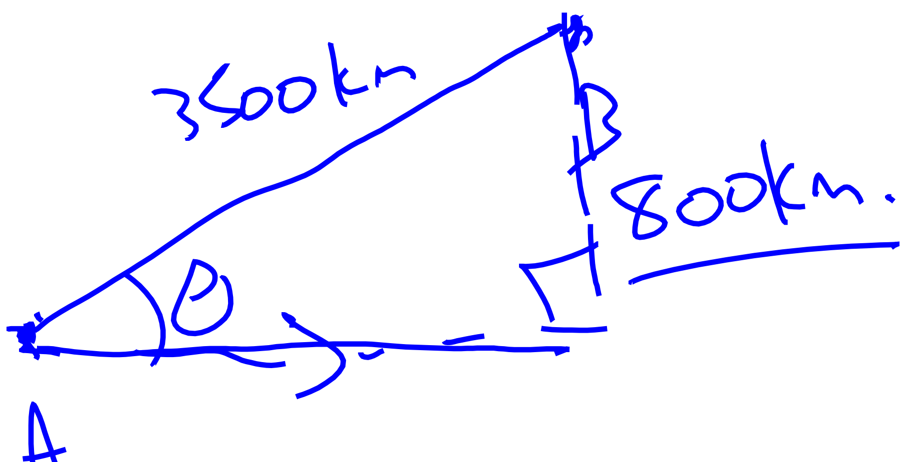
$$= \frac{3897.7 - 3500}{700\ \text{km/h}}$$

$= 0.568\text{h}$

$= \underline{34.1\ \text{min}}$

Detour example

↳ took ~ $\frac{1}{2}$ hr longer to get from A to B.



What is <u>displacement</u> from A to B?

method 1 of rcp vectors.

$\boxed{3500 \text{ km.}}$

$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$$

$$= \frac{800}{3500}$$

$$\theta = \arcsin\left(\frac{800}{3500}\right)$$

$$\sin^{-1}\left(\frac{800}{3500}\right)$$

$\theta = \underline{0.2306 \text{ rad}}$ w.r.t

+ve x dir

θ is also

13.4°.

method 2: use "coordinates"

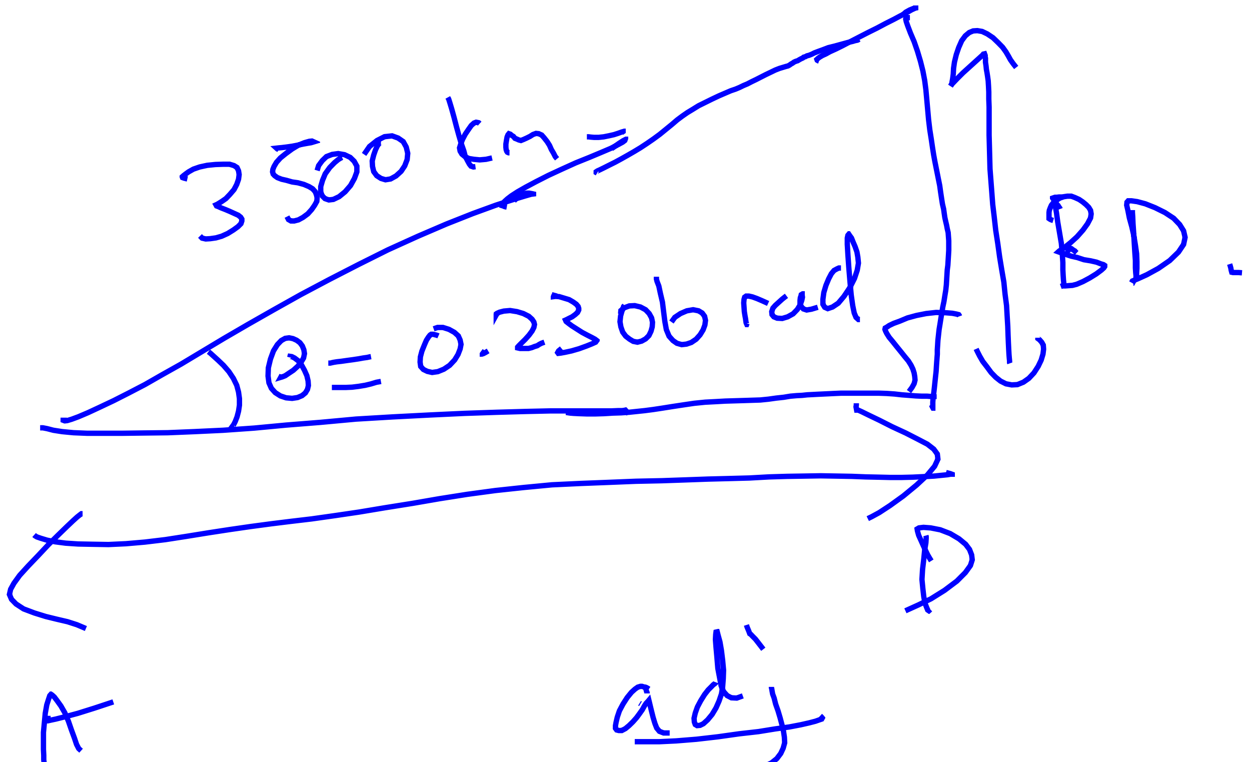
In 2D

$$\vec{S} = \begin{bmatrix} S_x \\ S_y \end{bmatrix}$$

where

$$S_x = 3407.3 \text{ km}$$

$$S_y = 800 \text{ km.}$$



$$\cos\theta = \frac{\text{adj}}{\text{hyp}}$$

$$AD = 3500 \times \cos\theta$$

$$= 3500 \times \cos(0.2306 \text{ rad})$$

$$= \underline{3407.3} \text{ km}$$

$$BD = 3500 \times \sin(0.2306 \text{ rad})$$

$$= 800 \text{ km}$$

Kinematics 2 vector addition.

$$\vec{S} = \vec{AB} = \begin{bmatrix} 2407.3 \\ 800 \end{bmatrix} \text{km.}$$

show

$$\vec{AB} = \vec{AC} + \vec{CB}$$

$$\vec{AC} = \begin{bmatrix} 3000 \\ 0 \end{bmatrix} \text{km.}$$

$$\vec{CB} = \begin{bmatrix} 407.3 \\ 800.0 \end{bmatrix} \text{km}$$

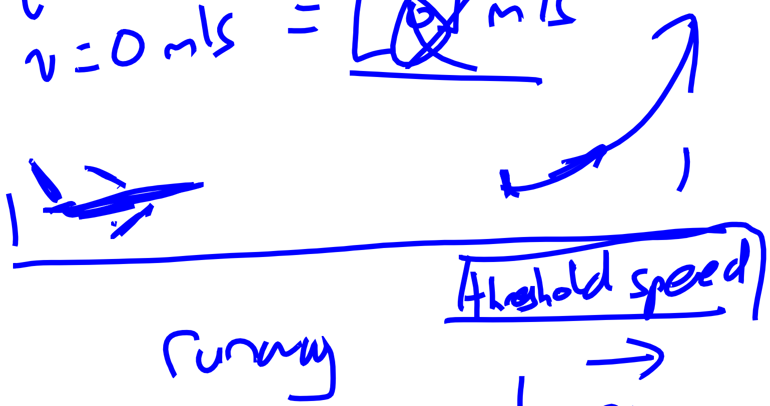
$$\vec{AB} = \begin{bmatrix} 3000 \\ 0 \end{bmatrix} \text{km} + \begin{bmatrix} 407.3 \\ 800 \end{bmatrix}$$

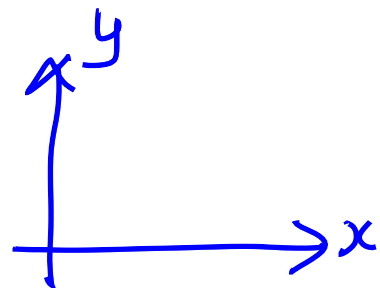
$$= \begin{bmatrix} 3407.3 \\ 800 \end{bmatrix} \text{km.}$$

Takeoff / Landing

$t = 0\,s$

$v = 0\,m/s = \begin{bmatrix} 0 \\ 0 \end{bmatrix} m/s$





$\rightarrow$ v_x

$t = 0\,s$

$v_x = 0\,m/s$

?

$\boxed{100\,m/s}$

1. we need to hit 100 m/s.
2. we need to accelerate the plane...

how much acceleration the plane can take $\rightarrow$ $0.7\,m/s^2$ ($0.7\,ms^{-2}$)

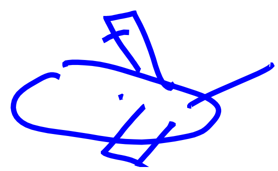
$\boxed{a_x}$

*

($\vec{a}$) acceleration is rate of chg of ($\vec{v}$) velocity w.r.t time.

acceleration limits

- Human body
- plane structure



fuselage.

$9 \times \cancel{9.81}\ 10$

$= 90\,m/s^2$

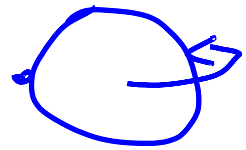
main limitation

pilots → up to 9g of acceleration.

g = gravitational acceleration of earth.

$10.0\,m/s^2$

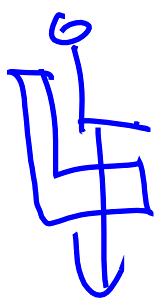
$9.80 - 9.81\,m/s^2$



gravity at equator is weaker than polar region.

↳ bulge effect

passenger → 0.2-0.5g max



→ 0.5g 10kg.

30kg 5kg.

60kg

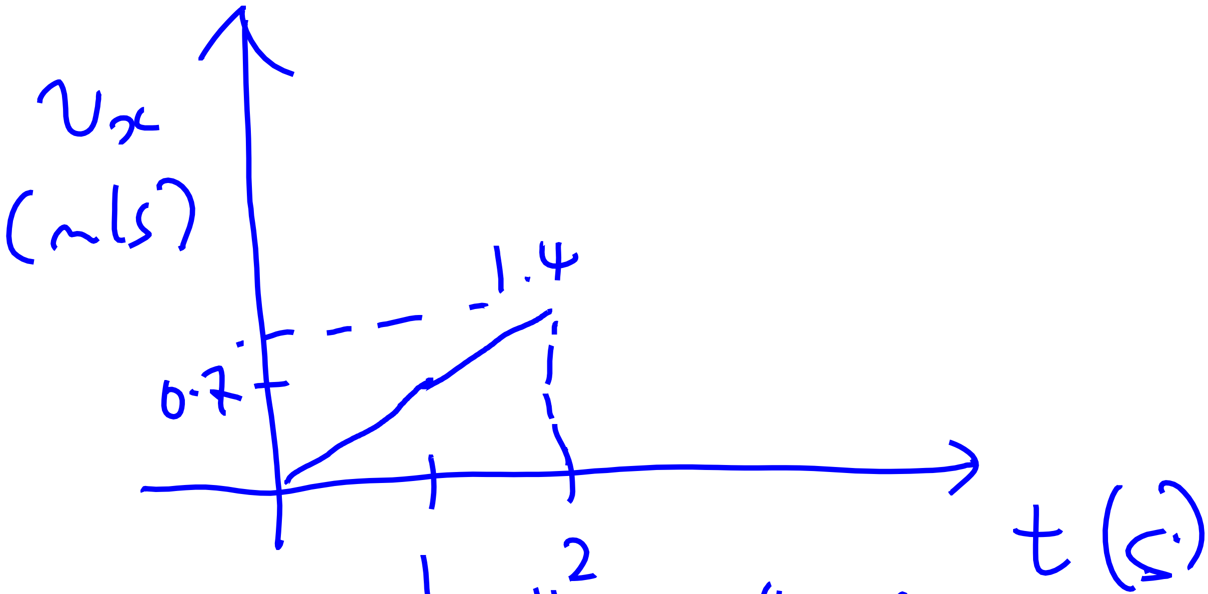
0.08g. 0.08g.

for passenger comfort → $0.7\ m/s^2$ acc max

$1.4\ m/s^2$

for acceleration problem. → assume const acceleration.

use v_x, t graph.



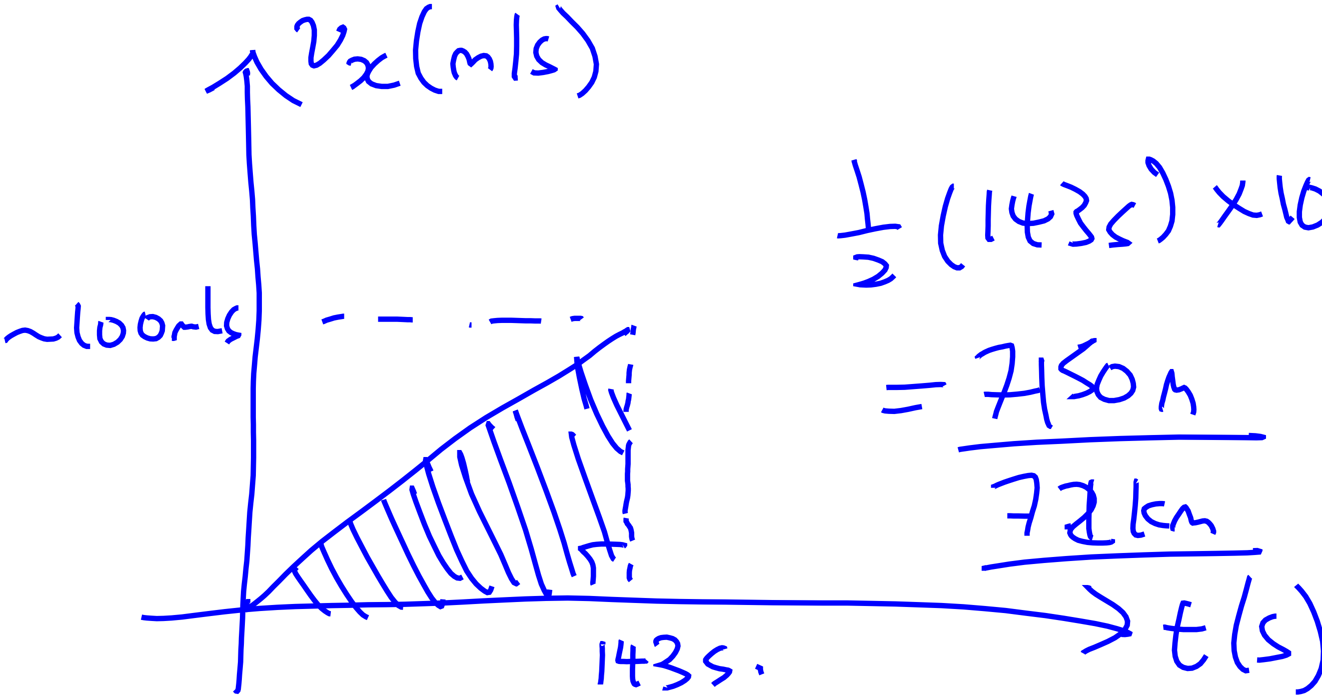
"Delta." → Greek letter used to denote chg in physics.

$$a_x = \frac{\Delta v_x}{\Delta t}$$

$=$

$$0.7\,ms^{-2} = \frac{100\,m/s - 0\,m/s}{t - 0\,s}.$$

$$t = \frac{100}{0.7} = 143\,s$$

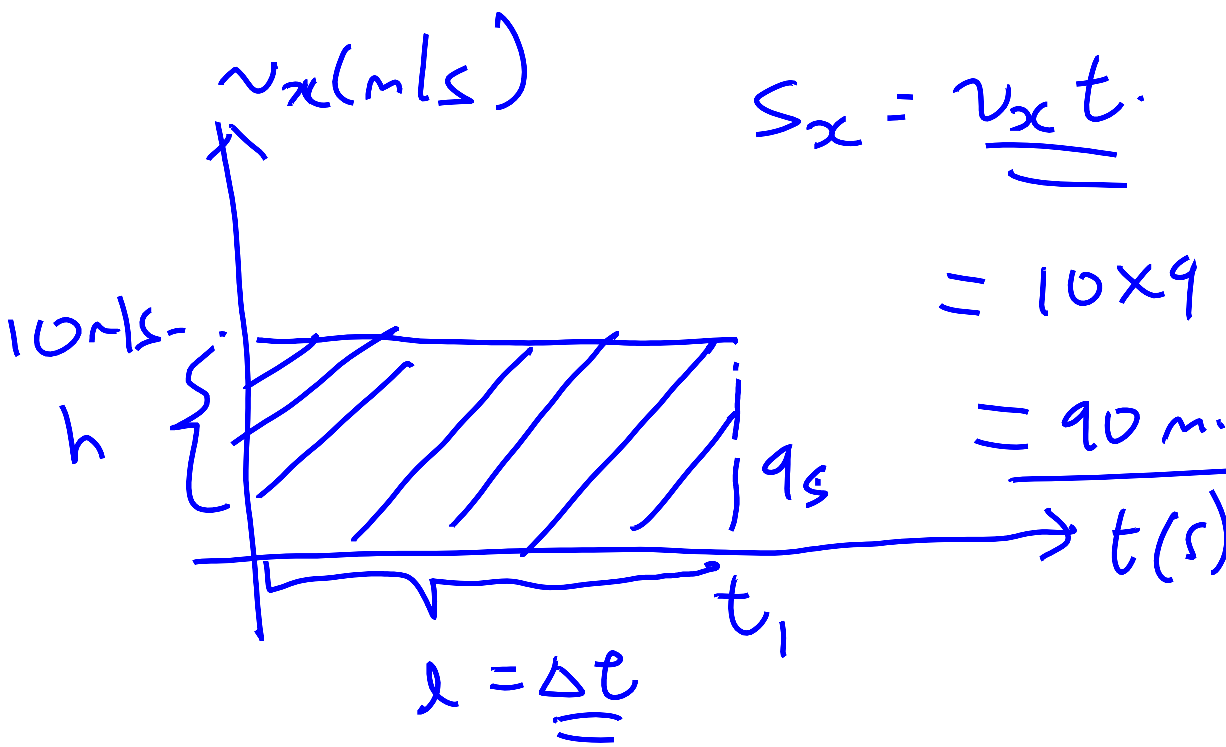


$\frac{1}{2}(143s) \times 100 m/s$

$= 7150 m$

$7.1 km$

How to calc distance.



$s_x = v_x t$

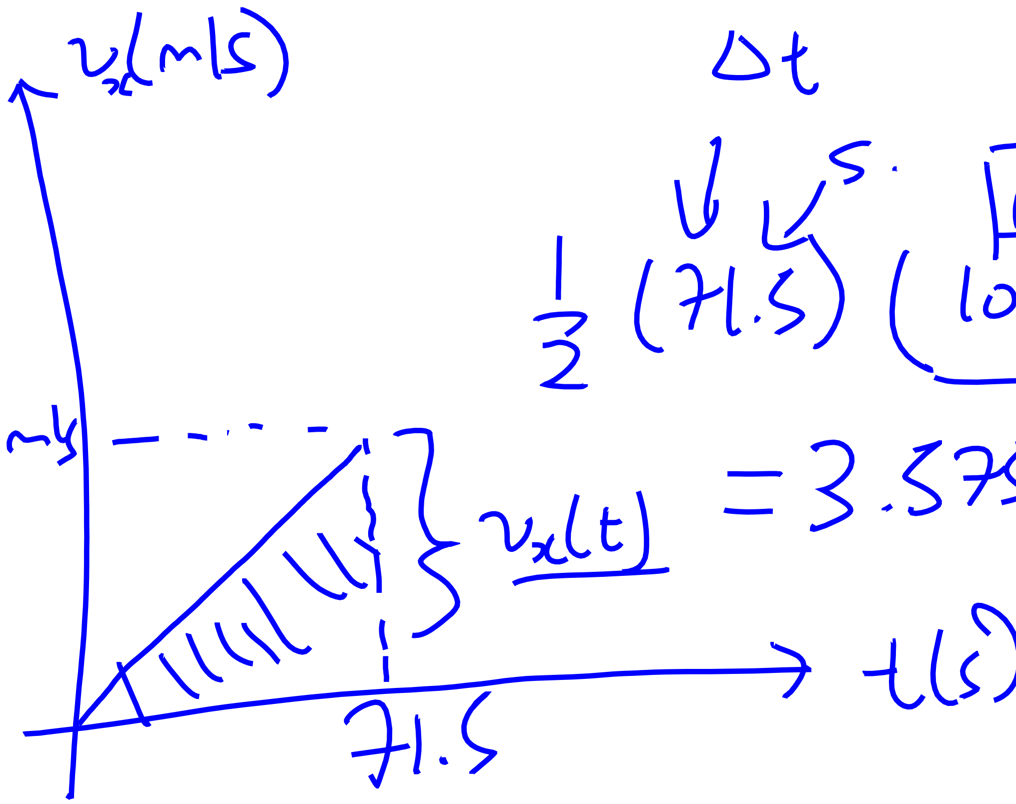
$= 10 \times 9$

$= 90 m.$

in $\underline{\text{velocity}}$ - time graph.
v_x

↳ area under graph = $\underline{\text{displacement}}$.
s_x

lets try with $\underline{\underline{1.4\ m/s^2}}$.



Δt

s. $\boxed{m/s}$.

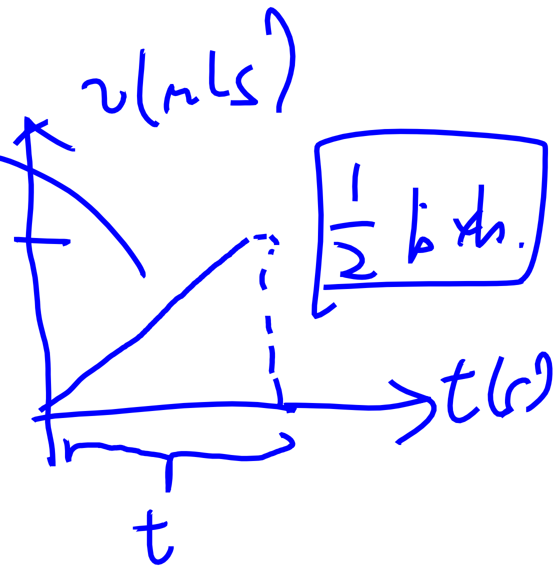
$\frac{1}{2}(71.5)(100)$

$= 3.575\ \underline{\underline{km}}.$

runways are limited by
space constraints.

For const acceleration.

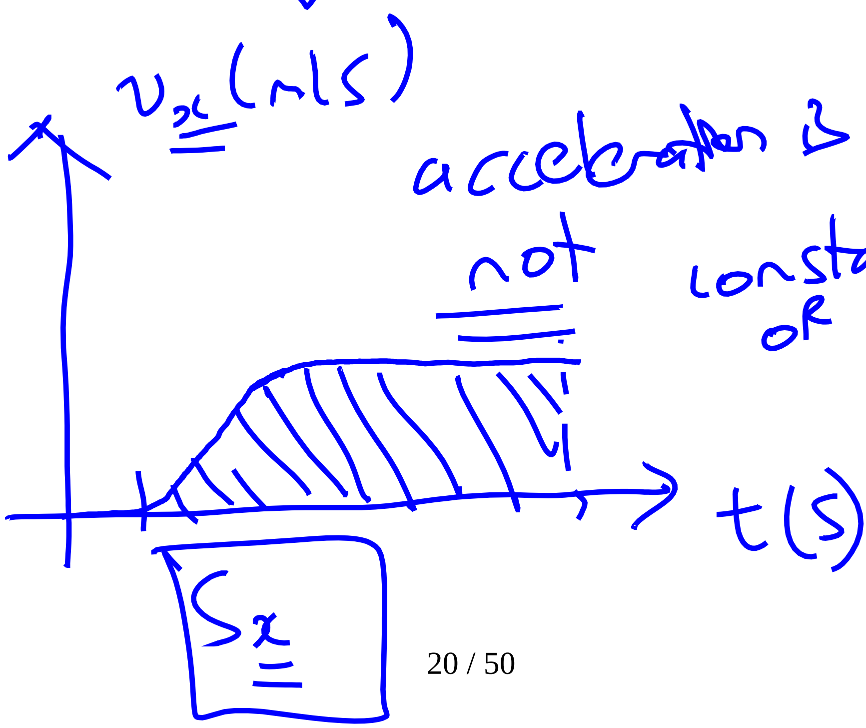
$$\boxed{S_x = \frac{1}{2} a_x t^2}$$

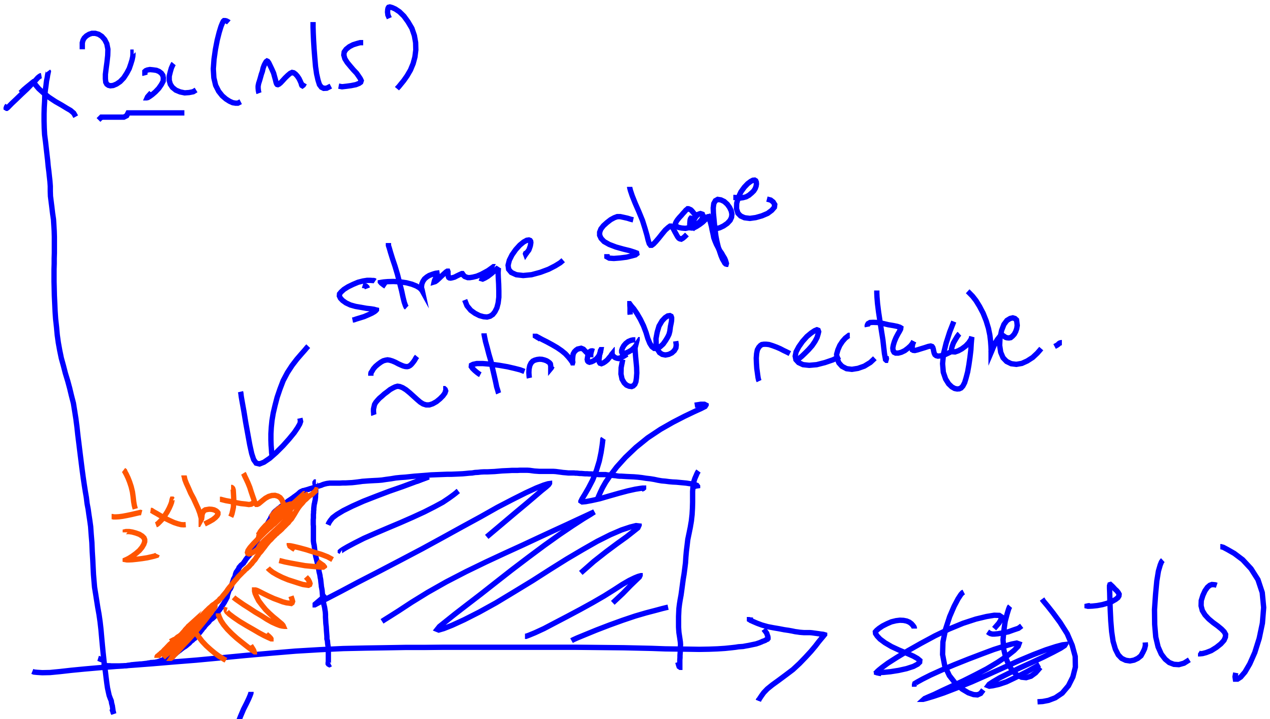


$$v_x(t) = at.$$

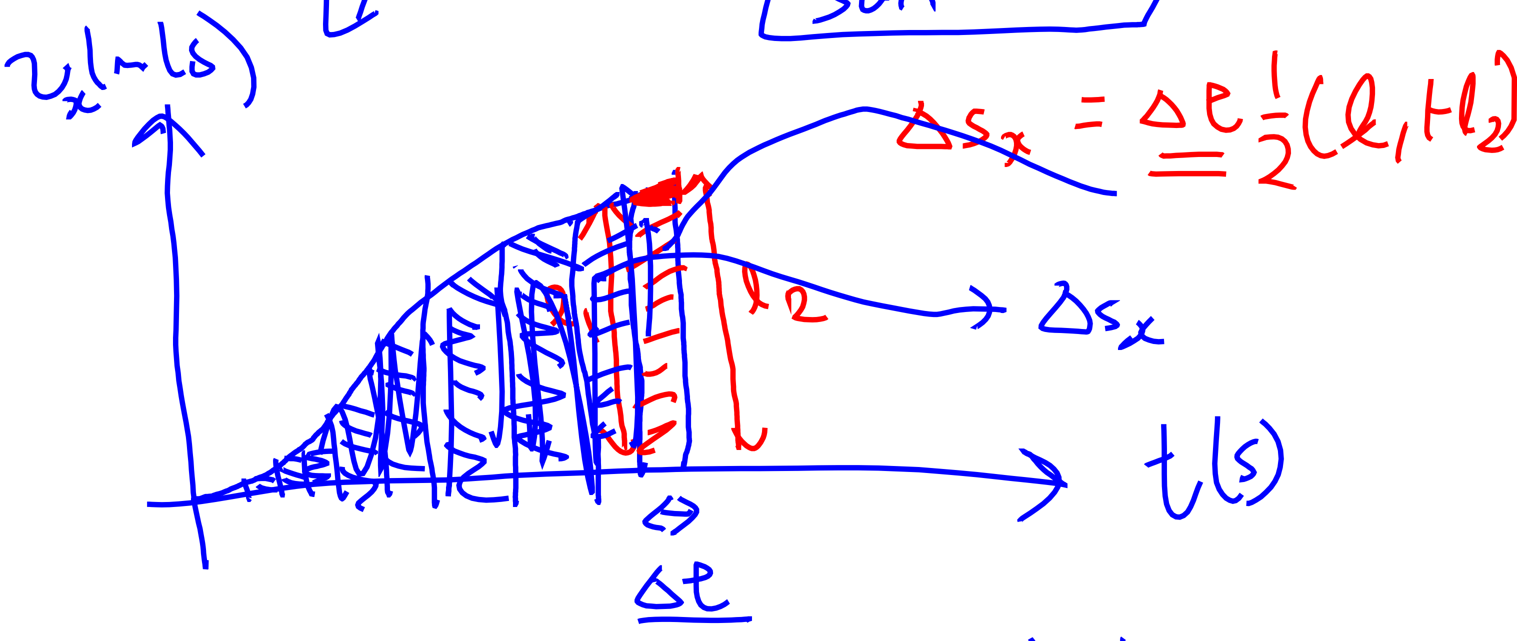
(velocity time graph).

The graph is most impt.





Area = $\boxed{\sum_{\text{sum}} \Delta s_x}$



If time interval is short,
(Δt)

then there is less curvature

$\boxed{\text{taking limits.} \quad \Delta t \to 0}$

$$\boxed{\sum v_x \, \Delta t \qquad \text{sum} \quad \lim_{\Delta t \to 0}}$$

integration

area under graph $= \displaystyle\int_{t=0}^{t=t_1} v_x \, dt.$

distorted "S" = Sum

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