#3

PhD ON RAIN-MAN Problems

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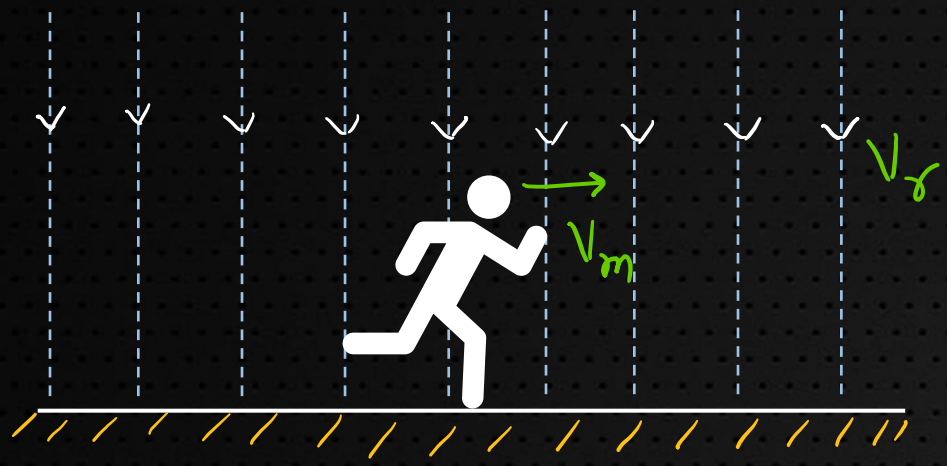

Rain-Man Problems

Kinematics (Relative Velocity)

PhD SERIES

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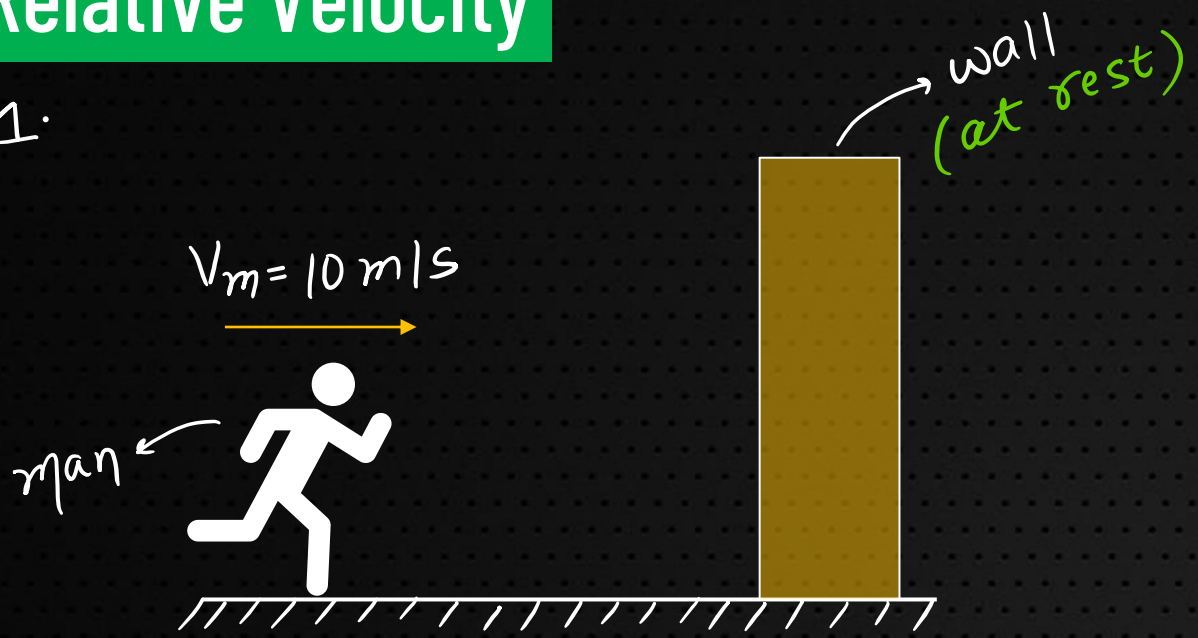
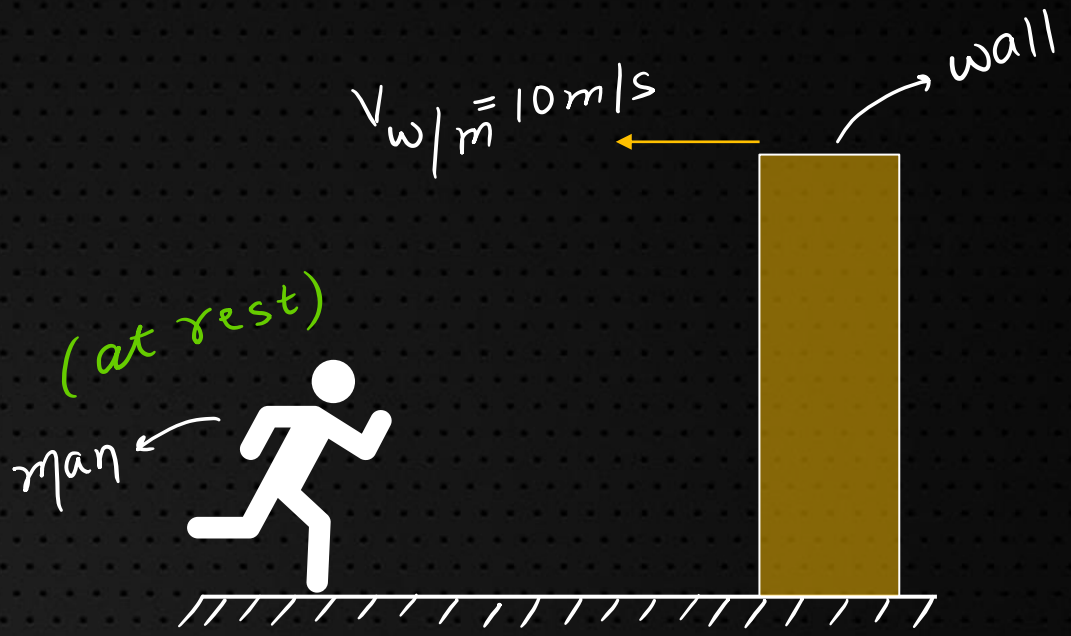
Relative Velocity

1.



Ground Frame



Man's Frame

$$\vec{V}_{w/m} = \vec{V}_w - \vec{V}_m$$

$$\Rightarrow \vec{V}_{w/m} = 0 - 10\hat{i}\ m/s$$

$$\therefore \vec{V}_{w/m} = -10\hat{i}\ m/s$$

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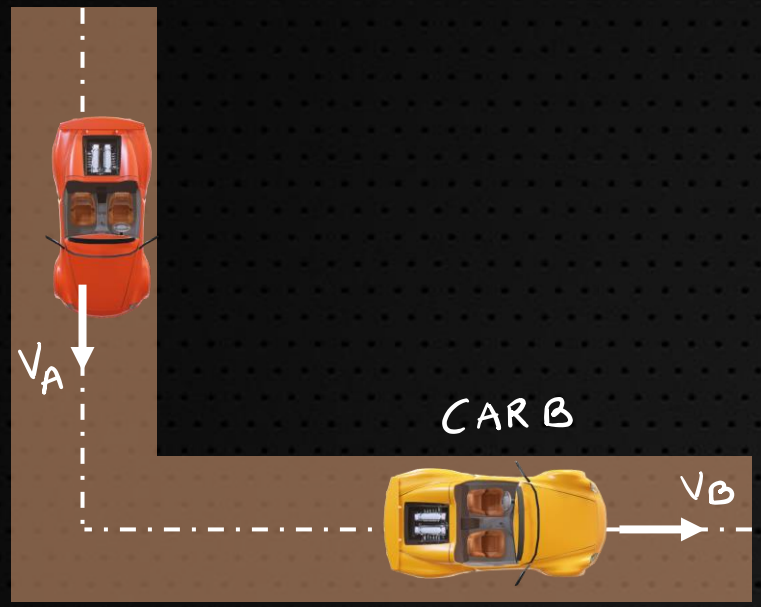
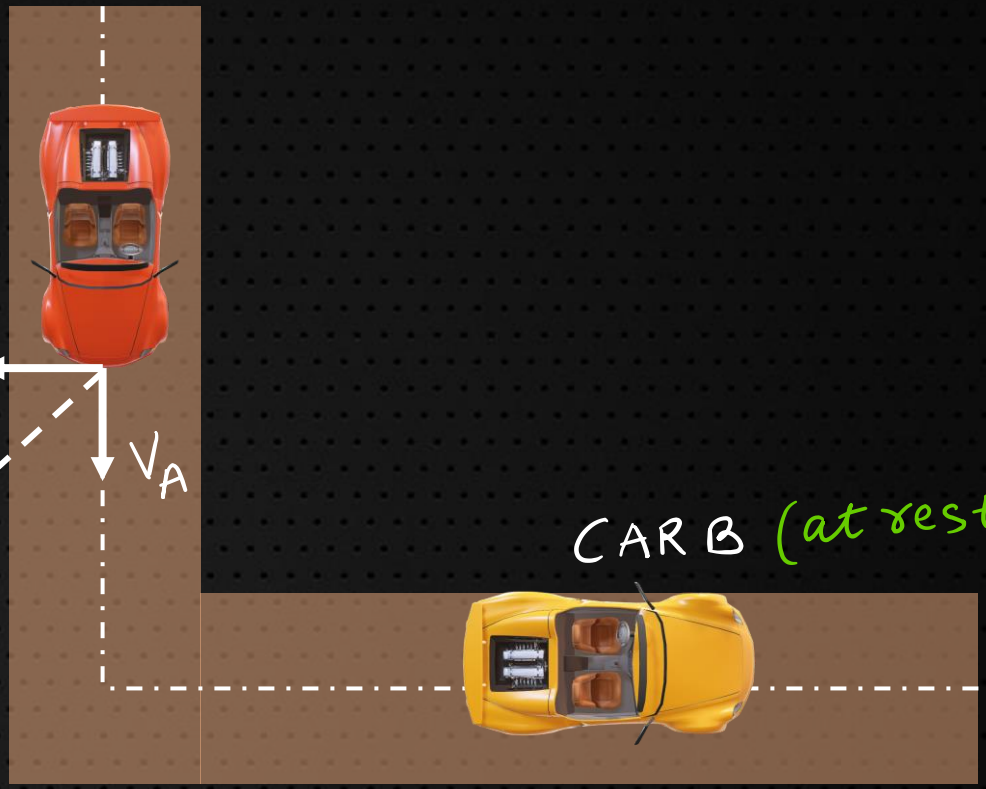
Relative Velocity

2.



Ground Frame



CAR B Frame

↳ To car B, car A appears to move in this direct with speed of $\sqrt{V_A^2 + V_B^2}$

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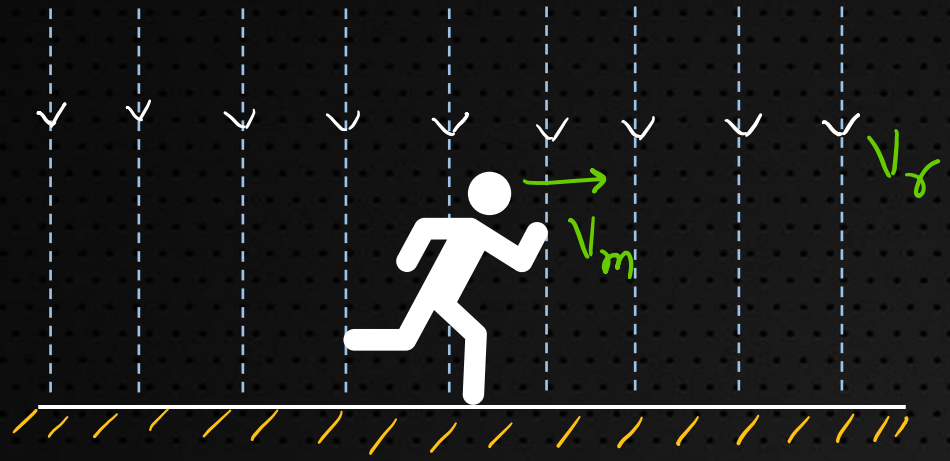
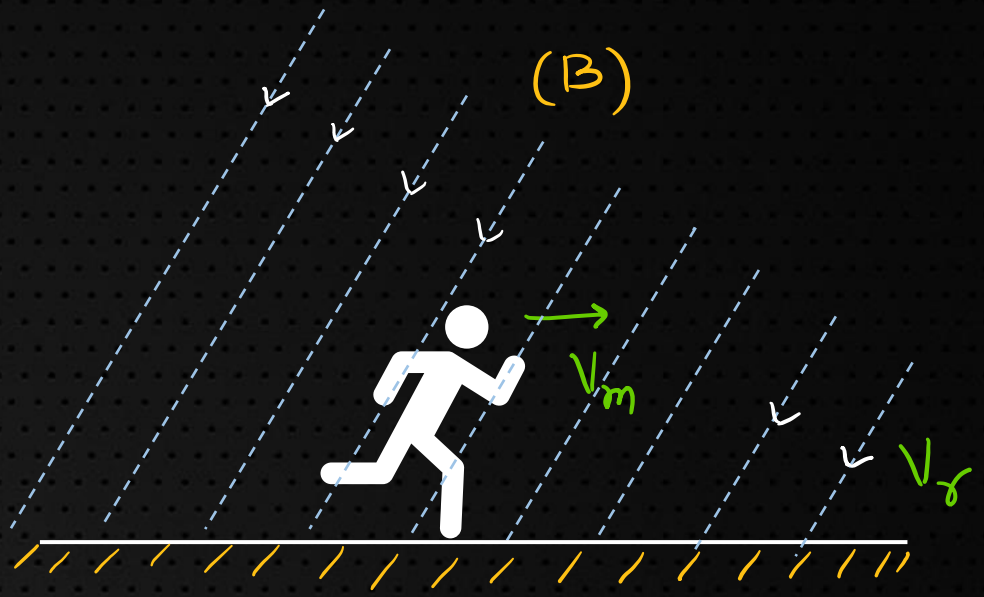
Rain-Man Problems

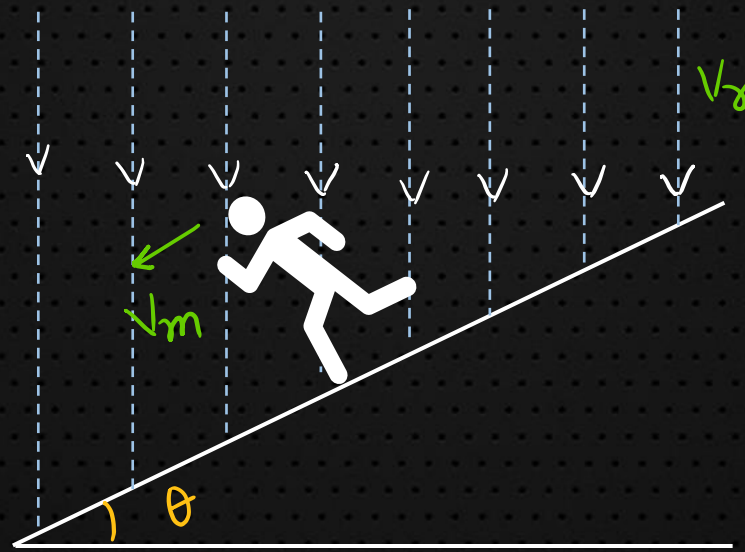
(A)



(B)



(C)

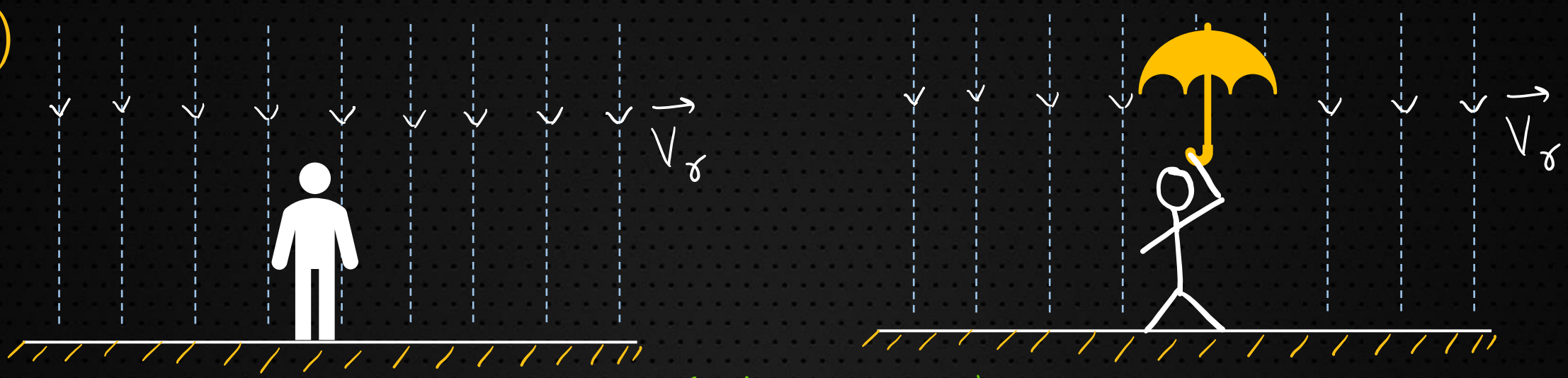


All Ground Frame

$\vec{V}_r, \vec{V}_m, \vec{V}_{r/m}$

Rain-Man Problems

(A)



Man at rest

↳ He has to hold umbrella as shown

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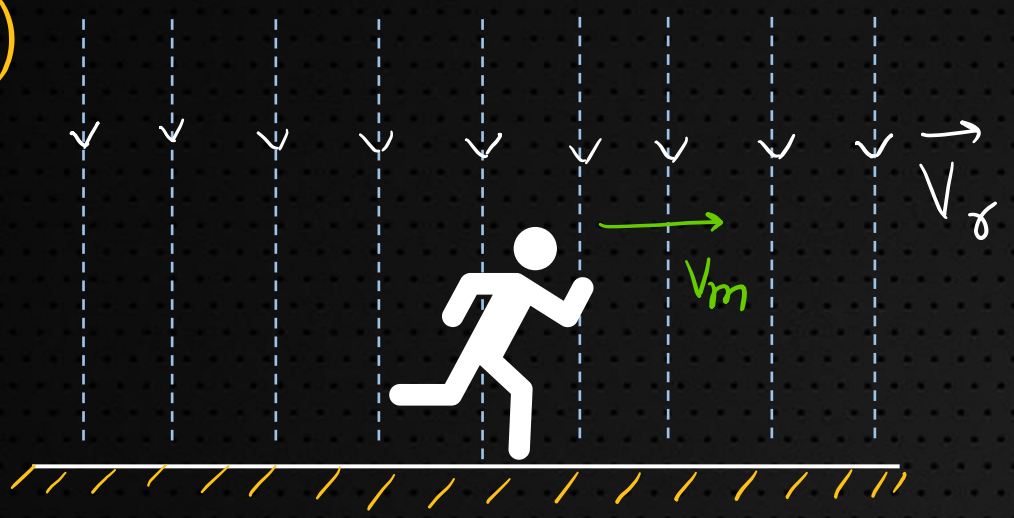
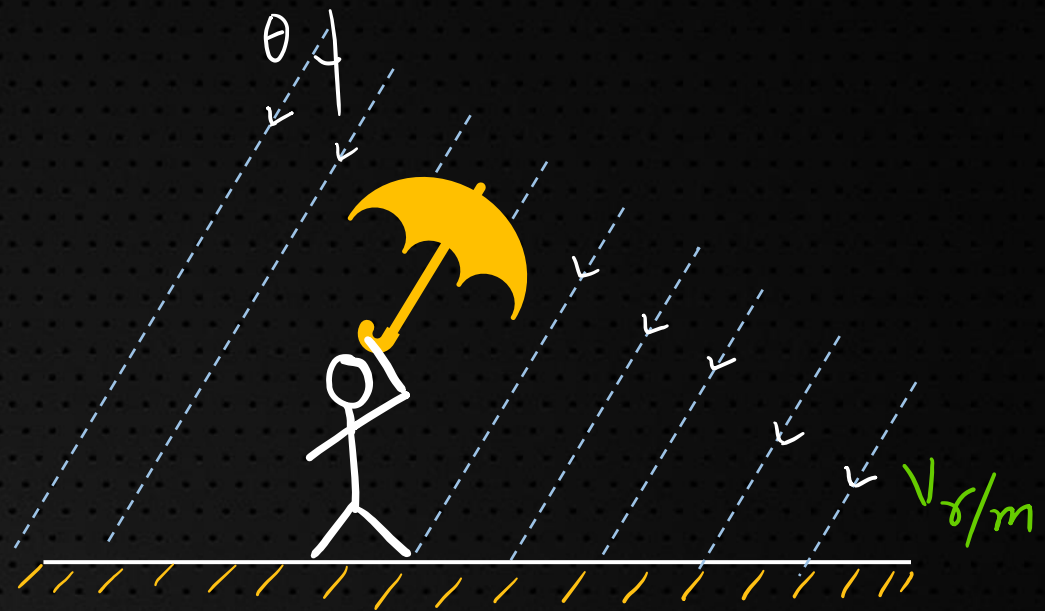
Rain-Man Problems

(A)

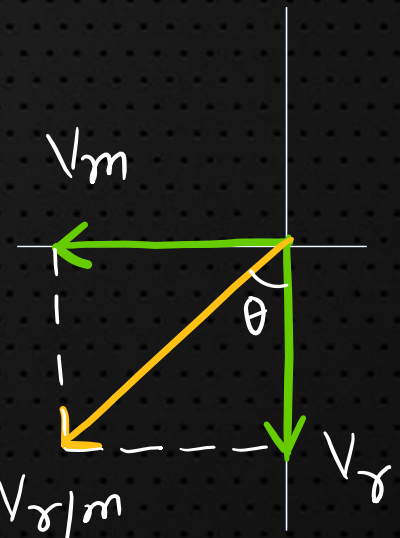


Ground Frame



Man's Frame

Man Running

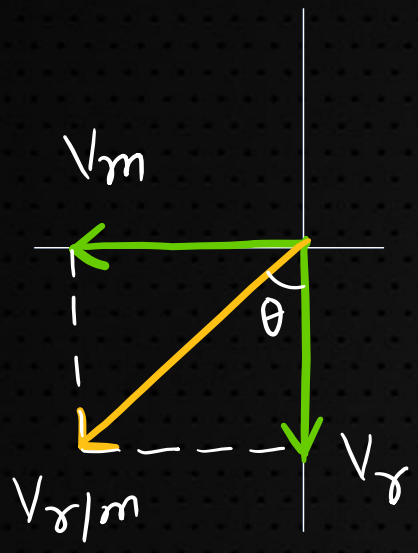


(i) $\tan\theta = V_m / V_r$

(ii) $V_{r/m} = \sqrt{V_m^2 + V_r^2}$

$\vec{V}_{r/m} = \vec{V}_r - \vec{V}_m$

Rain-Man Problems



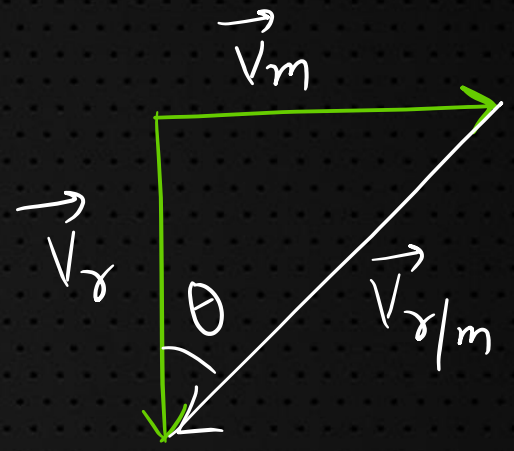
(i) $\tan\theta = V_m / V_r$

(ii) $V_{r/m} = \sqrt{V_m^2 + V_r^2}$

$\vec{V}_{r/m} = \vec{V}_r - \vec{V}_m$

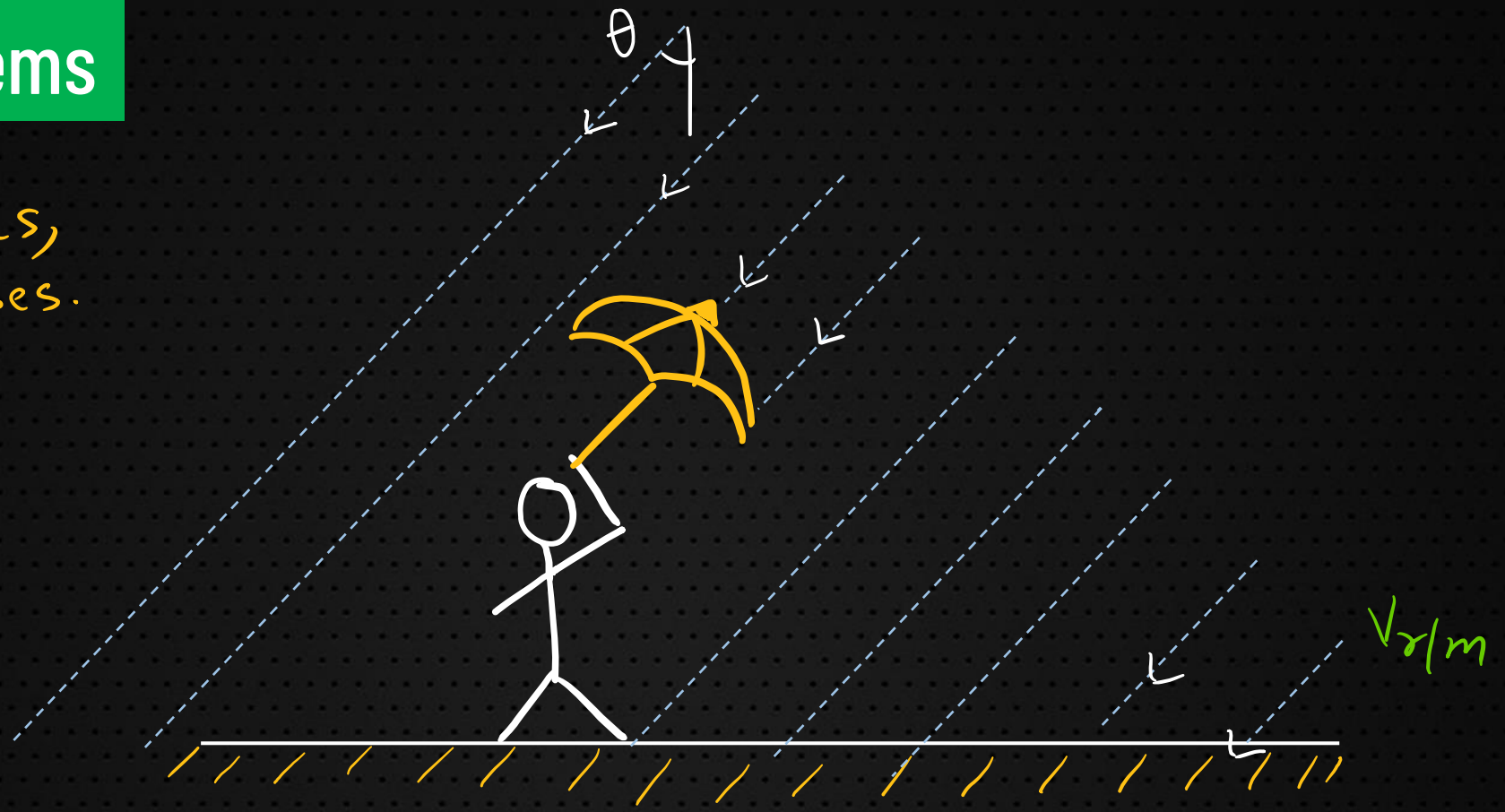
Another way:

$\vec{V}_r = \vec{V}_m + \vec{V}_{r/m}$



Rain-Man Problems

As V_m increases,
θ also increases.

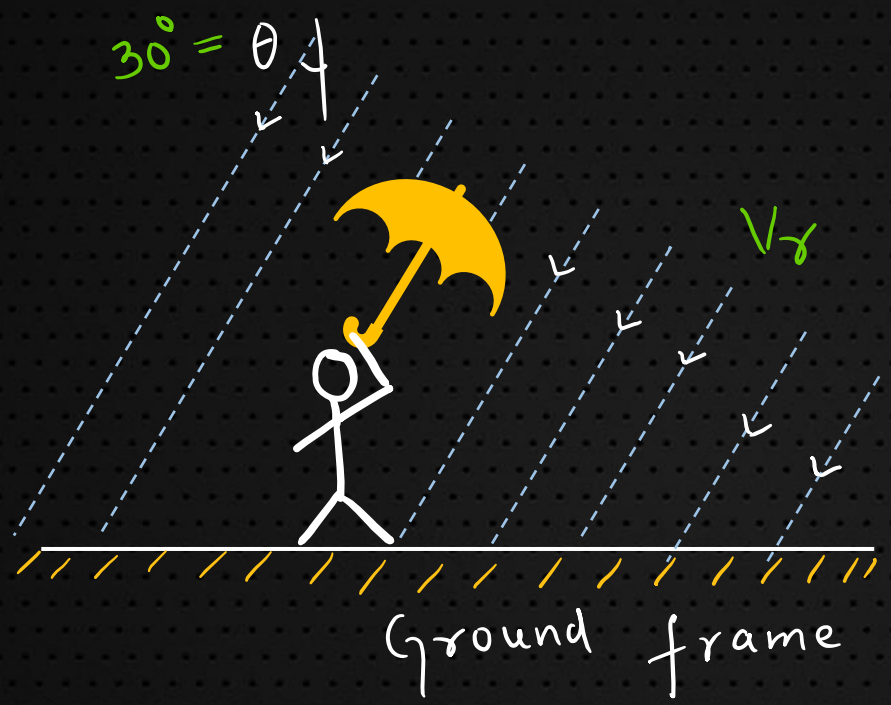


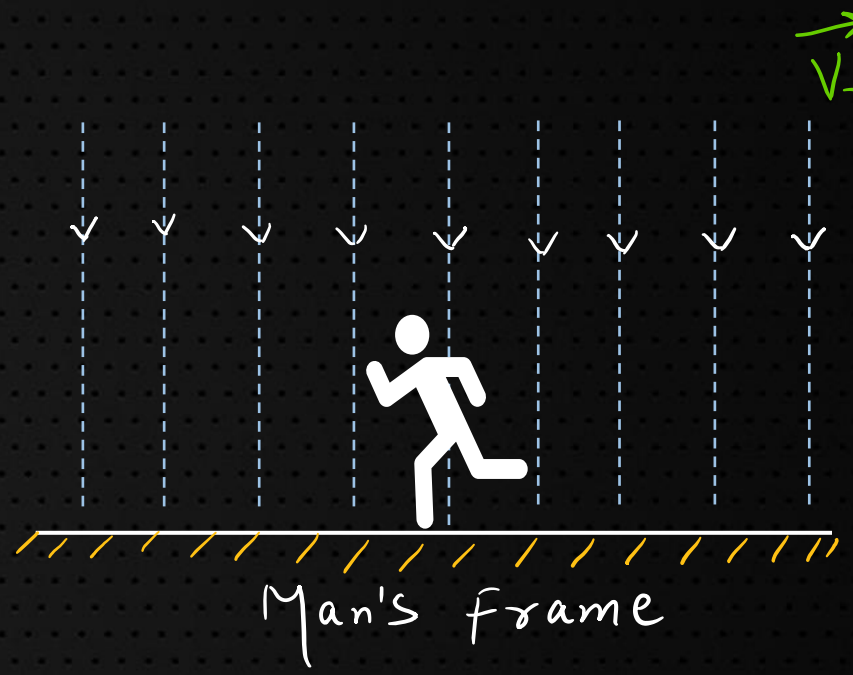
Man's Frame

Q1. *A man standing on a road has to hold his umbrella at 30° with the vertical to keep the rain away. He throws the umbrella and starts running at 10 km/h. He finds that raindrops are hitting his head vertically. Find the speed of raindrops with respect to (a) the road, (b) the moving man.*

Q1. **A man standing on a road has to hold his umbrella at 30° with the vertical to keep the rain away. He throws the umbrella and starts running at 10 km/h. He finds that raindrops are hitting his head vertically. Find the speed of raindrops with respect to (a) the road, (b) the moving man.**

Soln:





Given: (i) Dirⁿ of V_r

(ii) Dirⁿ of $V_{r/m}$

(iii) $V_m = 10$ Km/h and dirⁿ.

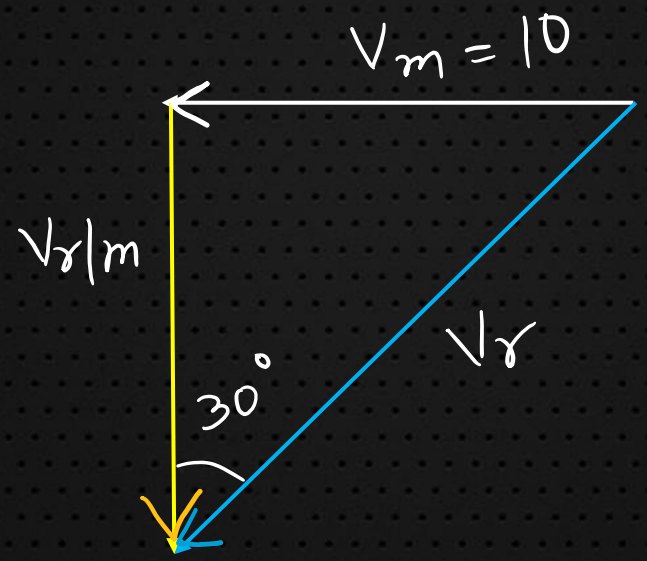
Q1. **A man standing on a road has to hold his umbrella at 30° with the vertical to keep the rain away. He throws the umbrella and starts running at 10 km/h. He finds that raindrops are hitting his head vertically. Find the speed of raindrops with respect to (a) the road, (b) the moving man.**

Sol^n: Given: (i) Dir^n of V_r

(ii) Dir^n of $V_{r/m}$

(iii) $V_m = 10$ Km/h and dir^n.

$\vec{V}_{r/m} = \vec{V}_r - \vec{V}_m \Rightarrow \vec{V}_r = \vec{V}_m + \vec{V}_{r/m}$



(a) $\sin 30° = \frac{V_m}{V_r}$

$\Rightarrow V_r = \frac{10}{1/2} = 20$ Km/h

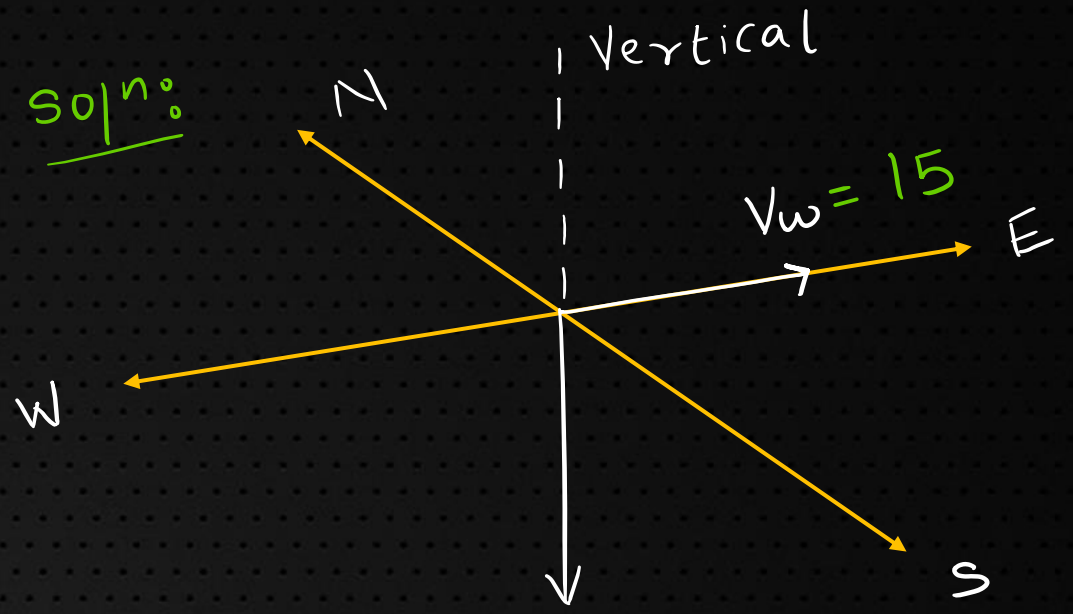
(b) $\tan 30° = V_m / V_{r/m}$

$\Rightarrow V_{r/m} = \frac{10}{1/\sqrt{3}} = 10\sqrt{3}$ Km/h

Q2. Rain is falling vertically with a speed of 20 ms^{-1} relative to air. A person is running in the rain with a velocity of 5 ms^{-1} and a wind is also blowing with a speed of 15 ms^{-1} (both towards east). Find the angle with the vertical at which the person should hold his umbrella so that he may not get drenched.

Q2. Rain is falling vertically with a speed of 20 ms^{-1} relative to air. A person is running in the rain with a velocity of 5 ms^{-1} and a wind is also blowing with a speed of 15 ms^{-1} (both towards east). Find the angle with the vertical at which the person should hold his umbrella so that he may not get drenched.

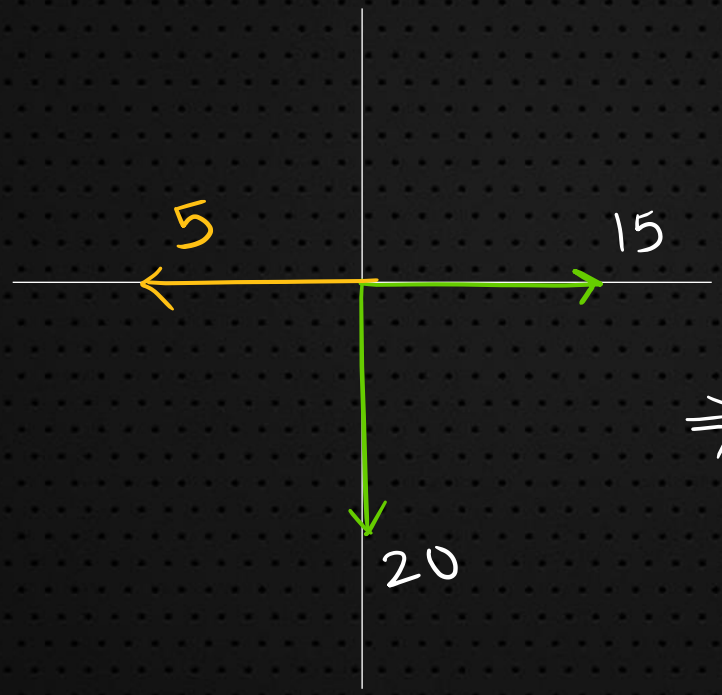
Soln:



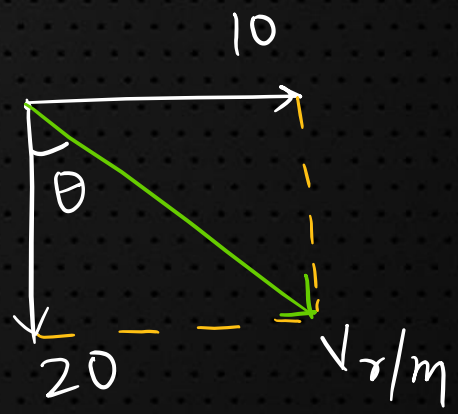
$\vec{V}_{r/w} = \vec{V}_r - \vec{V}_w$

$\Rightarrow \vec{V}_{r/w} = \vec{V}_r + (-\vec{V}_w)$

$\vec{V}_r = \vec{V}_w + \vec{V}_{r/w}$



$\Rightarrow$

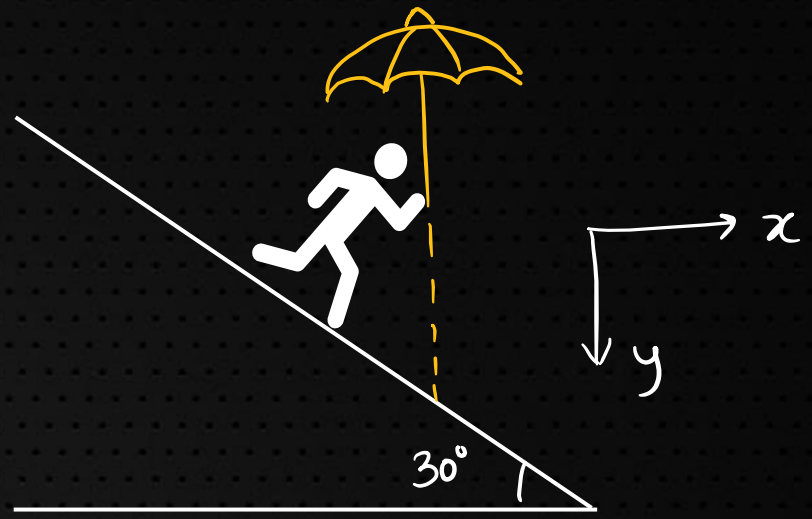


$\tan\theta = \frac{10}{20}$

$\therefore \theta = \tan^{-1}\frac{1}{2}$

Ans

Q3. A man is coming down an incline of angle 30°. When he walks with speed $2\sqrt{3}$ m/s, he has to keep his umbrella vertical to protect himself from rain. The actual speed of rain is 5 m/s. At what angle with vertical should he keep his umbrella when he is at rest so that he does not get drenched?



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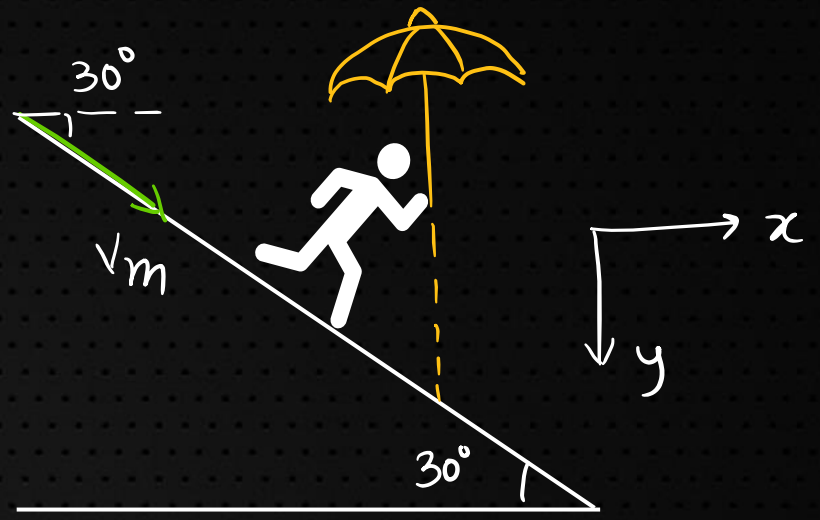


Soln: Given: (i) $V_m = 2\sqrt{3}$ m/s and direction

(ii) $V_{r/m}$ direction (Vertically down)

(iii) $V_r = 5$ m/s

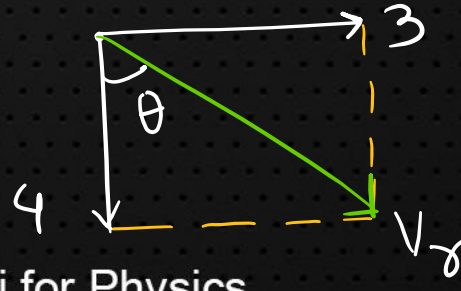
To Find: direction of V_r

$\vec{V}_{r/m} = \vec{V}_r - \vec{V}_m \Rightarrow \vec{V}_r = \vec{V}_m + \vec{V}_{r/m}$

$\Rightarrow a\hat{i} + b\hat{j} = (3\hat{i} + \sqrt{3}\hat{j}) + V_{r/m}\hat{j}$

$\therefore \boxed{a = 3}$ also, $\sqrt{a^2+b^2} = 5 \Rightarrow b = \sqrt{25-9}$

$= 4$ m/s



$\tan\theta = 3/4$

$\therefore \boxed{\theta = 37°}$ Ans.

PYQs (2020, 2021)

Concept Videos

Advanced Problems

Part and Full Test

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