Title: Physics in Nature Presentation: Running in the Rain

Date: Aug 19, 2011 09:00 AM

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Abstract:

RUNNING IN THE RAIN

Physics in Nature, PSI 2011-2012 A

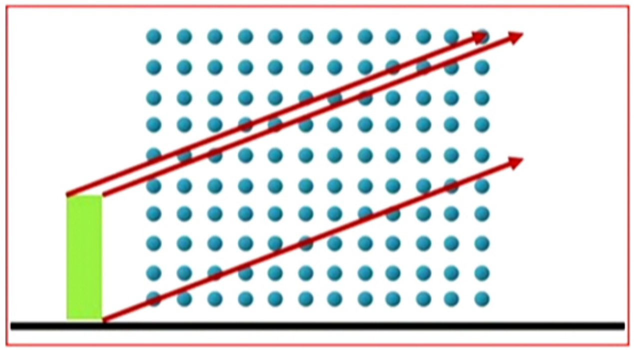
MOTIVATION

- Heavy rains on Sunday afternoon made it annoying to get to PI.

- If rain catches us by surprise (no umbrella), what should we do?

A SIMPLE MODEL

- Human-rain system: Box shaped human running against the rain, no cross wind.



- Conservation of rain droplets:

$$\nabla \cdot \vec{j} = \frac{\partial \rho_{wet}}{\partial t} \rightarrow \int \vec{j} d\vec{S} = \frac{\partial}{\partial t} \int \rho_{wet} dV = \frac{\partial Q}{\partial t}$$

- $$[\vec{j}] = \frac{drop}{m^2 s}, [Q] = drop$$

FURTHER SIMPLIFICATIONS

- Rain field homogeneously distributed, the current is then constant. Flux is easily obtained:
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$$\vec{j} = \rho_{wat}\vec{v}$$

$$\frac{\partial Q}{\partial t} = \int \vec{j} d\vec{S} = d_{ss}\rho_{wat}\left(h \mid v_p - v_x \mid + w v_y\right)$$

- Getting wet rate gets higher with the velocity.

INTEGRATING OVER TIME

- If we consider fixed distance:

$$\Delta x = v_p t$$

$$Q = \Delta x \rho_{wat} \left(h \mid 1 - \frac{v_x}{v_p} \mid + w \frac{v_y}{v_p} \right)$$

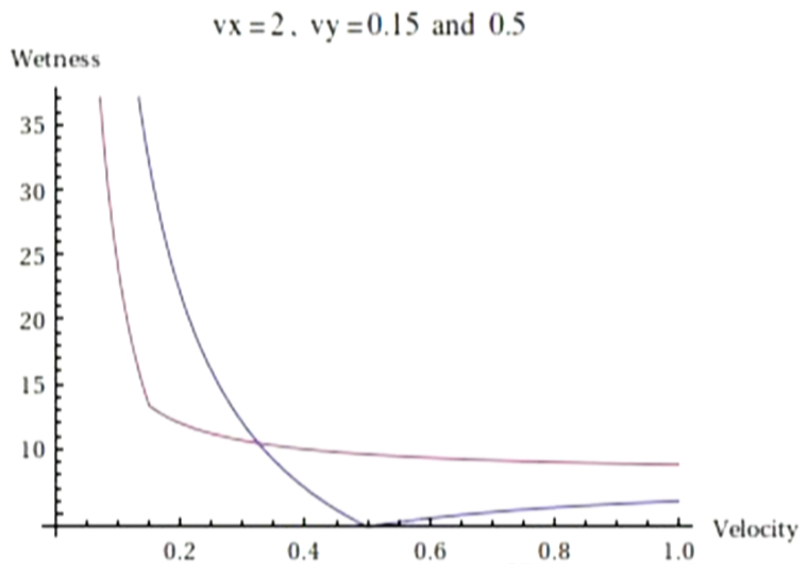
- Because of the absolute value, there may be a minimum when the velocity is the same than the one from rain. Asymptotics like we expected:
-

$$v_p \to 0 : Q \to \infty$$

$$v_p \to \infty : Q \to \Delta x \rho_{wat} d_{ss} h$$

BEHAVIOUR Q(v)

- Depending on our h/w ratio and the wind (velocity field of the rain) we can get less wet if we adjust our velocity to be the same than the horizontal on the rain. Some plots for h/w=8:

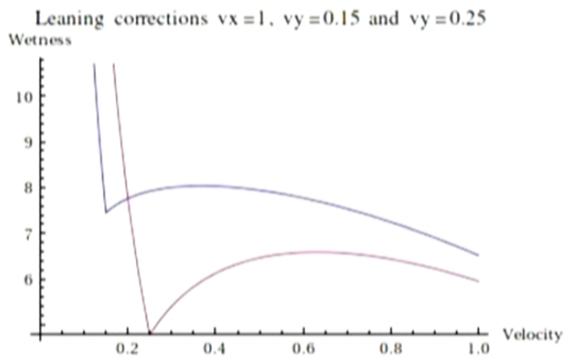


FURTHER CONSIDERATIONS

- People tend to lean when they run, suppose it linear in velocity:

$$\Delta x = v_p t$$

$$Q = \Delta x \rho_{wat} \left(h \,|\, 1 - \frac{v_x}{v_p} \,|\, \cos\left(\frac{\pi}{4}\frac{v_p}{v_{max}}\right) + w\frac{v_y}{v_p}\left(1 + \sin\left(\frac{\pi}{4}\frac{v_p}{v_{max}}\right)\right)\right)$$



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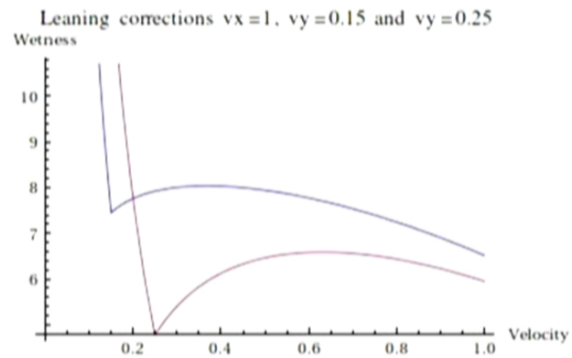


FURTHER CONSIDERATIONS

- Another simple consideration to implement would be to consider that our clothes aren't fully absorving the water.

$$\nabla \cdot \vec{j} = \frac{1}{\alpha}\frac{\partial \rho_{wet}}{\partial t} \rightarrow \rho_{eff-wat} = \alpha \rho_{wat}$$

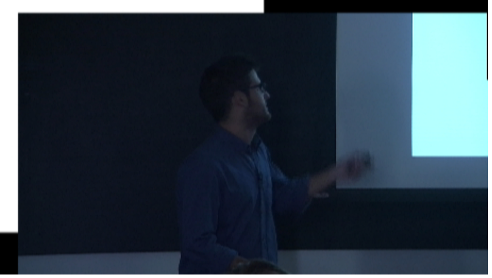
- Impermeability could be represented in our study just changing the density of water for an effective value.

POSSIBLE EXTENSIONS

- Relativistic models
- Other shapes (ellipsoid)
- External factors: Possibility of slipping vs velocity, ...

BIBLIOGRAPHY

- *I only read the articles* @ BlogSpot



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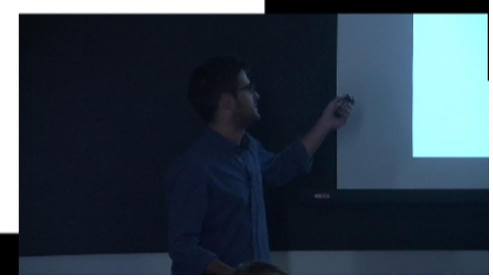

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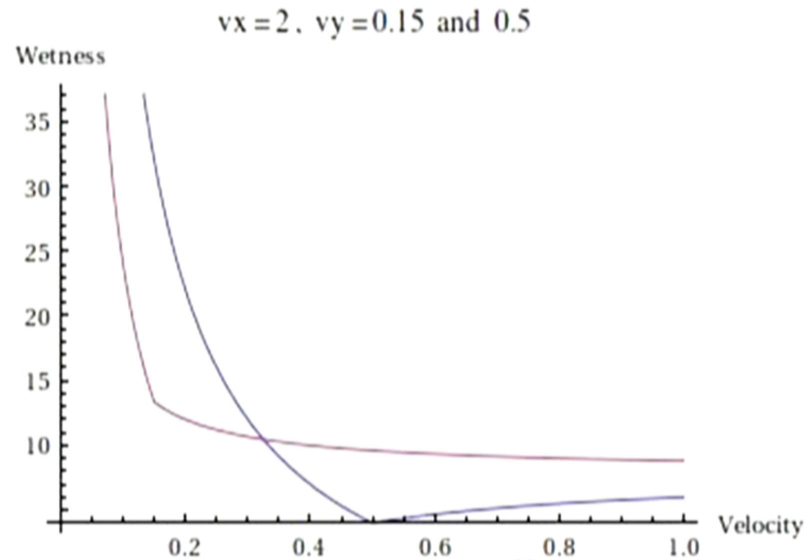

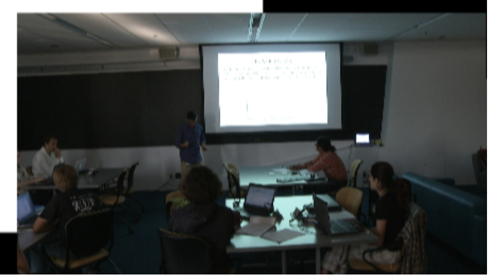

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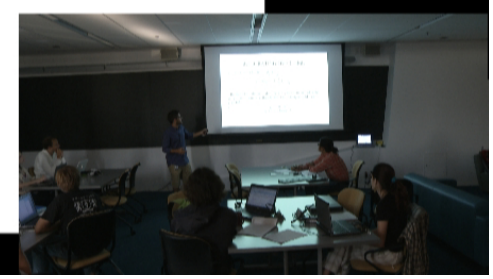

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