Relative Motion

Frames of Reference

Vectors – 2-D Kinematics

I. Vector Addition/Subtraction
   - Graphical

II. Vector Components
   - Applications

III. Vector Addition/Subtraction
   - Numerical

IV. Relative Motion

V. Projectile Motion

	The student will be able to:	HW:
1	Add or subtract vectors graphically and determine a vector's opposite.	✓ 1, 2
2	Calculate the components of a vector given its magnitude and direction.	✓ 3, 4
3	Calculate the magnitude and direction of a vector given its components.	✓ 5 - 9
4	Use vector components as a means of analyzing/ solving 2-D motion problems.	✓ 10 - 13
5	Add or subtract vectors analytically (using trigonometric calculations).	✓ 14, 15
6	Use vector addition or subtraction as a means of solving relative velocity problems.	16 - 20
7	State the horizontal and vertical relations for projectile motion and use the same to solve projectile problems and apply vector properties to projectile motion.	21 - 38

Frame of Reference

- Any quantity of motion must be measured *relative* to a certain frame of reference.
- A *frame of reference* is something with which a moving object is compared.
- The values of position, velocity, acceleration, etc. depend upon the chosen frame of reference.

  (The values could be *anything*, depending on *which* frame of reference is used!)

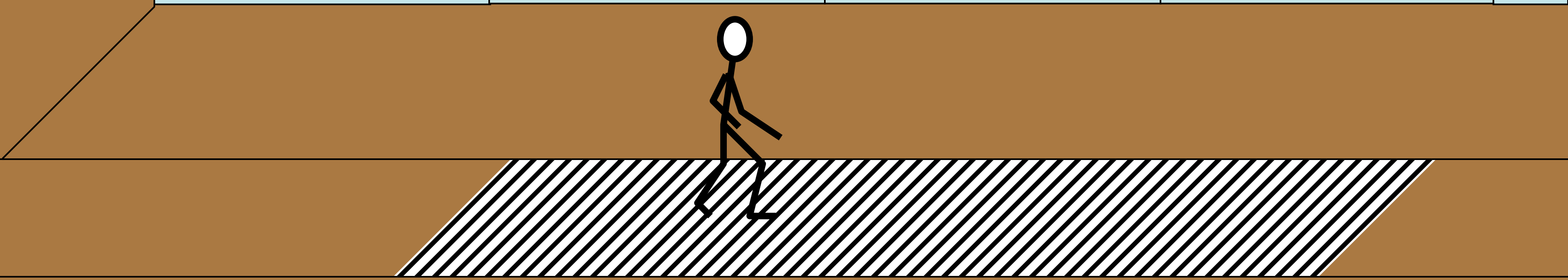
Relative Velocity Equation

For any three things A, B, and C it can be shown that the velocity of A relative to C is given by:

$$\vec{v}_{A/C} = \vec{v}_{A/B} + \vec{v}_{B/C}$$

The second letter in each subscript is the *frame of reference*.

Imagine a man walking on a moving sidewalk. The velocity relative to earth is different than the velocity relative to the sidewalk's surface. If the man is walking 1 m/s and the sidewalk is moving 2 m/s then the man moves 3 m/s through the building and over the earth.



$$\vec{v}_{P/E} = \vec{v}_{P/S} + \vec{v}_{S/E}$$

person relative to earth	person relative to sidewalk	sidewalk relative to earth

Relative Velocity of an Aircraft

A common application of the relative motion concept is in the analysis of the velocity of an aircraft. Pilots use the terms "groundspeed" and "course" to describe velocity relative to earth and the terms "airspeed" and "heading" to describe velocity relative to air.

$$\vec{v}_{P/E} = \vec{v}_{P/A} + \vec{v}_{A/E}$$

Plane relative to Earth	Plane relative to Air	Air relative to Earth

https://www.youtube.com/watch?v=gF9n7ShkOJ0

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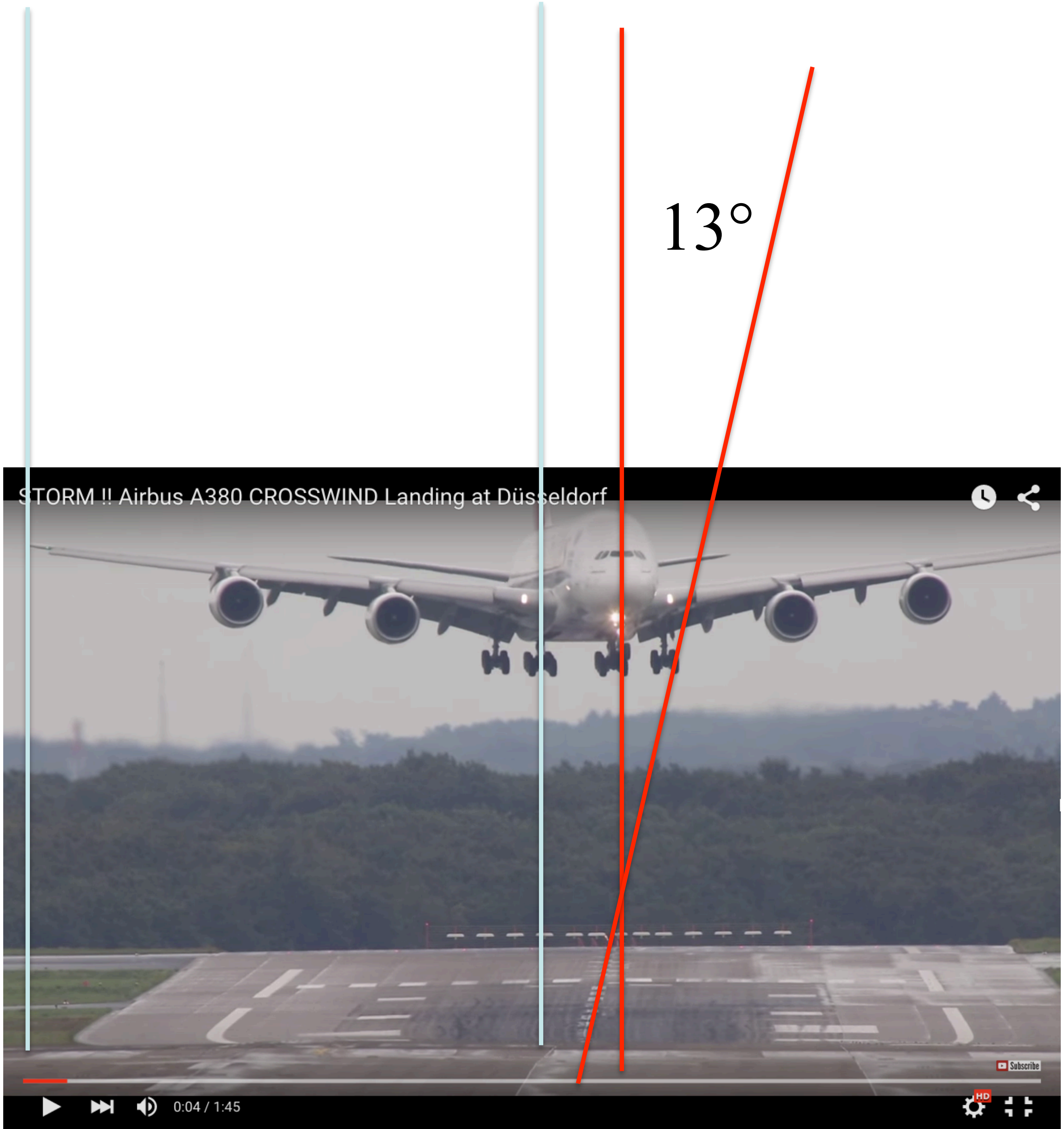
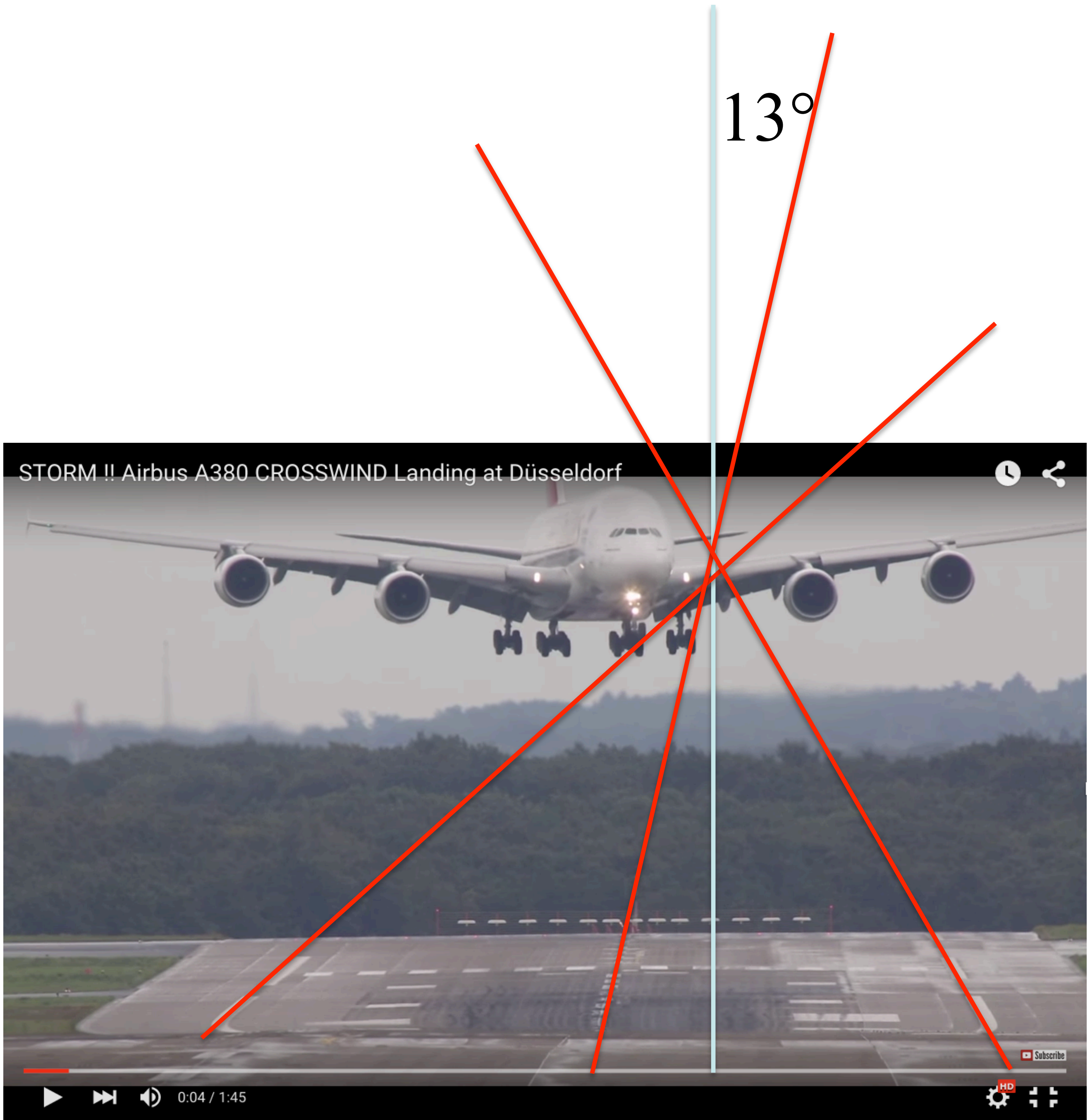
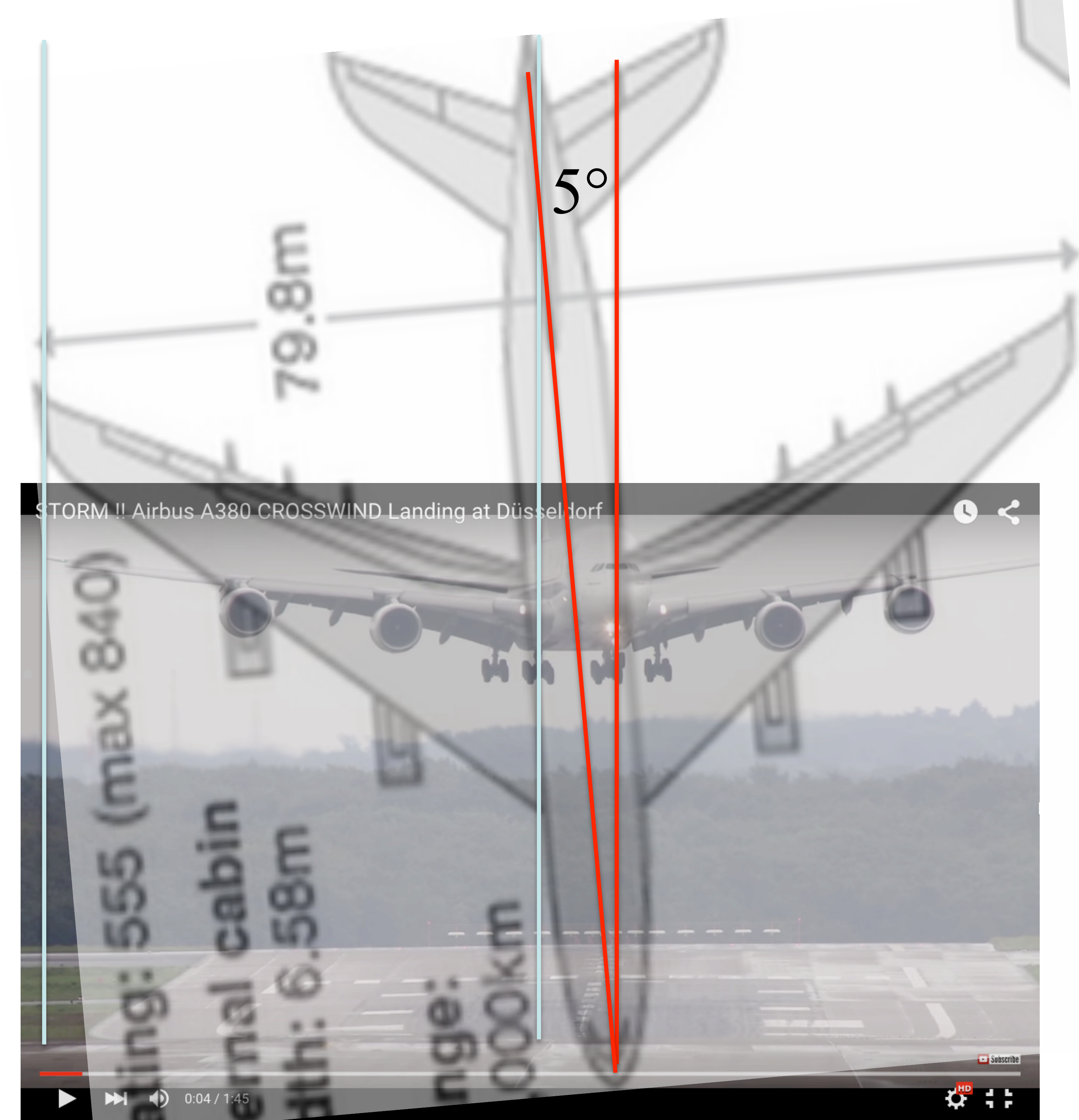

13°
STORM !! Airbus A380 CROSSWIND Landing at Düsseldorf
Subscribe
0:04 / 1:45
HD



13°
STORM !! Airbus A380 CROSSWIND Landing at Düsseldorf
0:04 / 1:45



5°
79.8m
STORM !! Airbus A380 CROSSWIND Landing at Düsseldorf
555 (max 840)
6.58m
0:04 / 1:45

The Airbus A380 lands with airspeed 245 km/h and heading 18° east of south. The course of the runway is due south. Find the speed of the crosswind. Compare to the published maximum crosswind of 75 km/h!