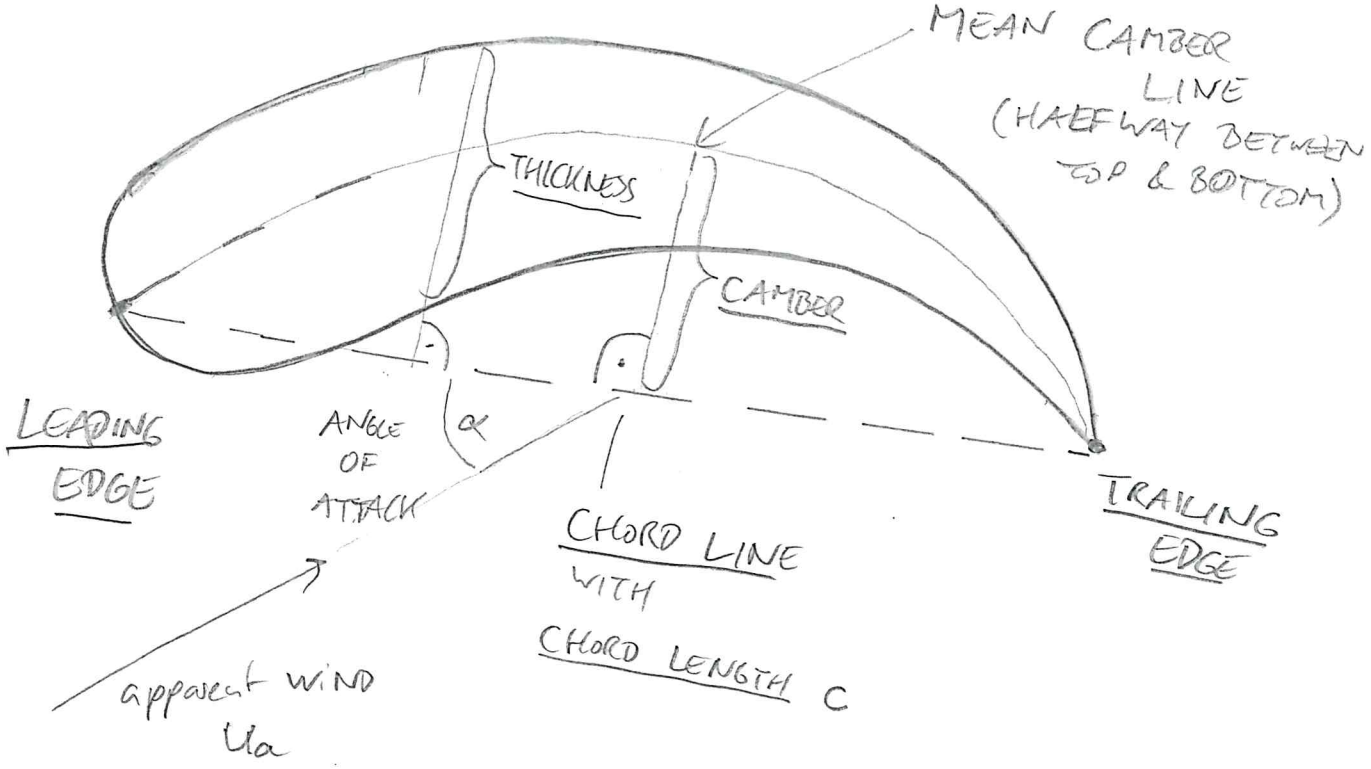
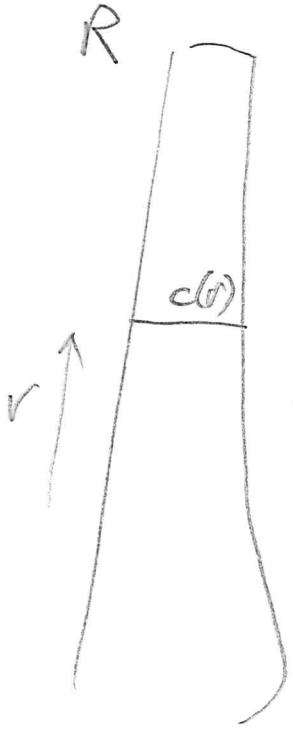
1.5 BLADE AND AIRFOIL NOMENCLATURE



CHORDWISE-DIRECTION IS ALONG CHORD LINE

SPANWISE-DIRECTION IS ORTHOGONAL, ALONG RADIAL DIRECTION

"SURFACE AREA" OF BLADE, BY DEFINITON: CHORD × SPAN = A



$$A = \int_0^R c(r)\, dr$$

AERODYNAMIC FORCES ARE OFTEN "PER SPAN", E.G. TOTAL AERO. FORCE ON A BLADE.

$$\vec{F}_{AERO} = \int_0^R \left(\vec{F}_L(r) + \vec{F}_D(r)\right) dr$$

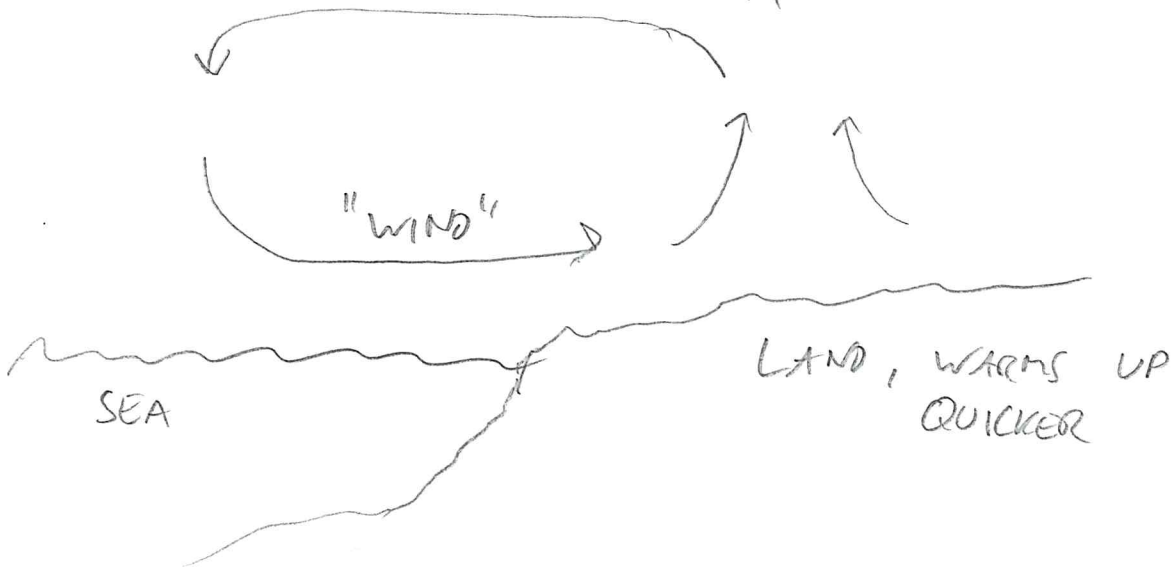
WITH $\vec{F}_{L,D}(r) = \frac{1}{2} \rho\, c(r)\, C_{L,D}\, |\vec{V}_a(r)|^2 \cdot \vec{e}_{L,D}$

2 THE WIND RESOURCE

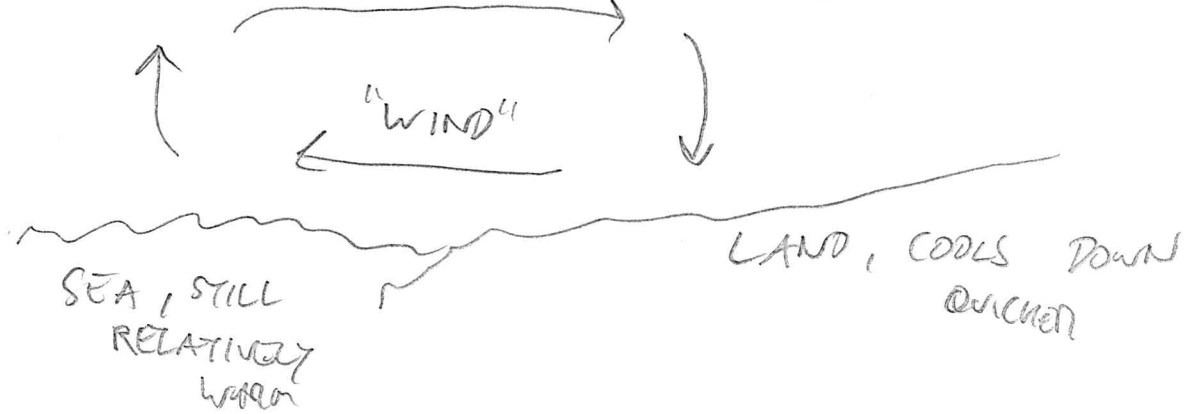
2.1 ORIGINS

- AIR HEATS UP (BY THE SUN, DIRECT OR INDIRECT)
- AIR DENSITY DROPS
- AIR RISES AND CREATES LOW PRESSURE REGION
- OTHER AIR FILLS THE GAP: "WIND"

EXAMPLE 1: SUNNY DAY AT COAST

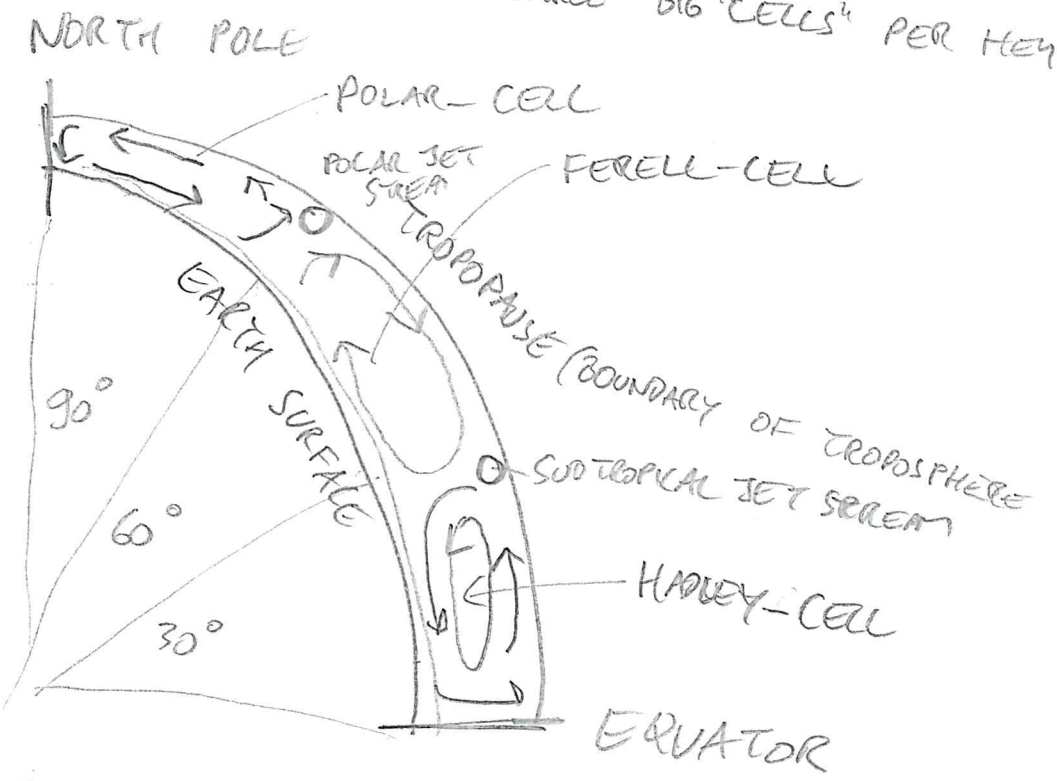


EXAMPLE 2: CLEAR NIGHT AT COAST



2.2 GLOBAL PATTERNS

AIR MOVES WITHIN TROPOSPHERE (5–15 Km ALTITUDE)
THREE BIG "CELLS" PER HEMISPHERE

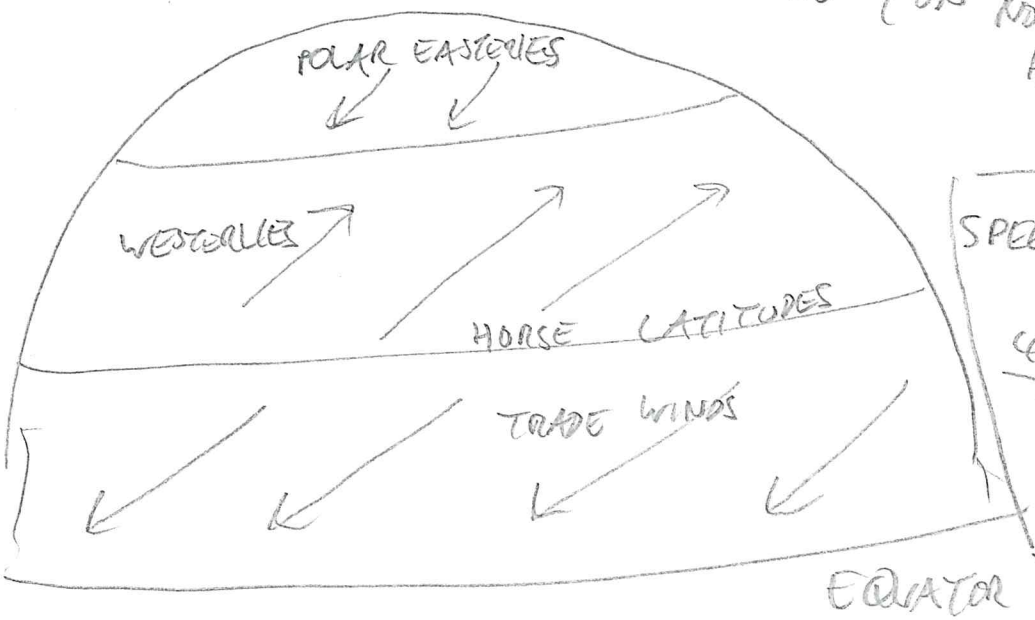


NOTE 1: FERREL CELL INDIRECTLY DRIVEN, BY HADLEY & POLAR CELL

NOTE 2: 10 000 Km FROM NORTH POLE TO EQUATOR

5–15 Km THICKNESS OF TROPOSPHERE (0.1%)

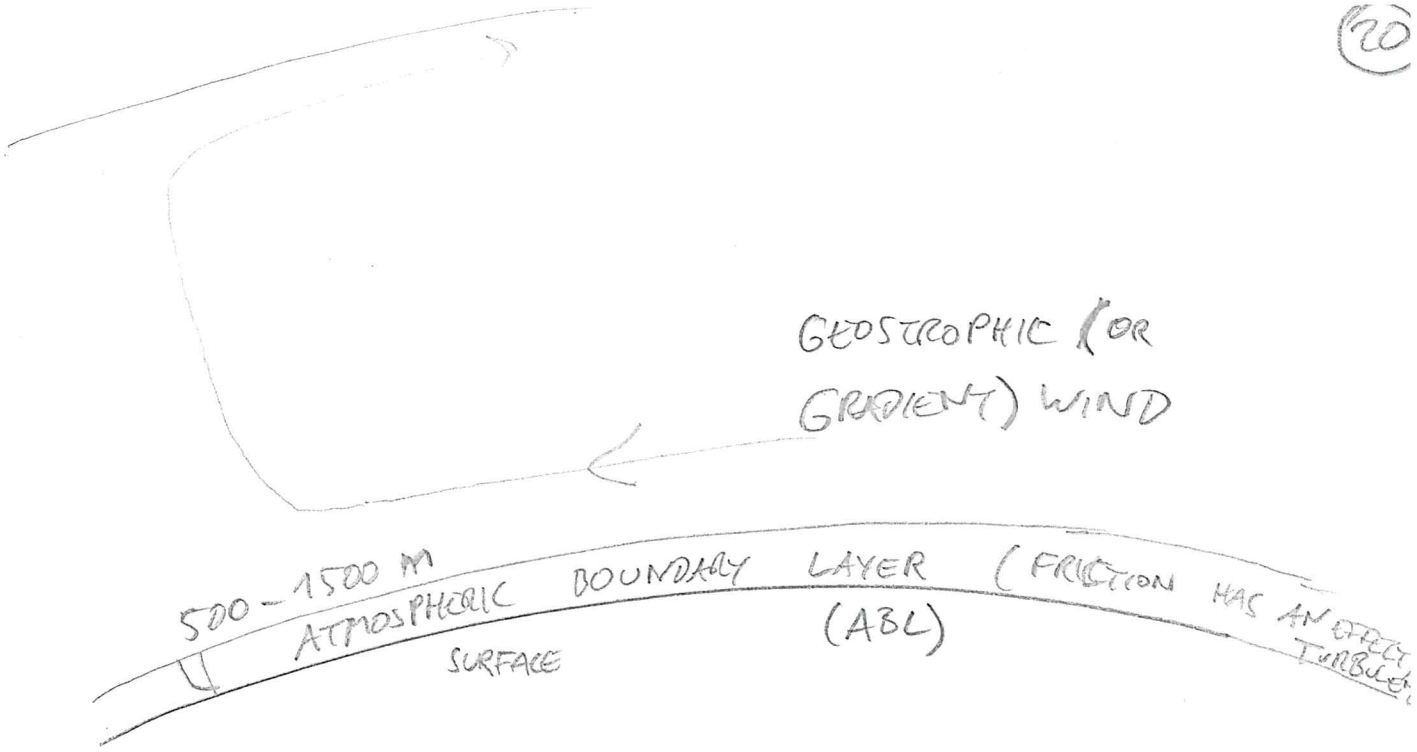
NOTE 3: DUE TO CORIOLIS FORCE, MOTION GETS DEVIATED TO RIGHT HAND SIDE (ON NORTHERN HEMISPHERE)



SPEED AT EQUATOR:

$\frac{40000\ km}{24\ h} = 1670\ \frac{km}{h}$

FASTER THAN SOUND



STRONG WIND SHEAR IN ABL

(MAGNITUDE & DIRECTION CHANGE)

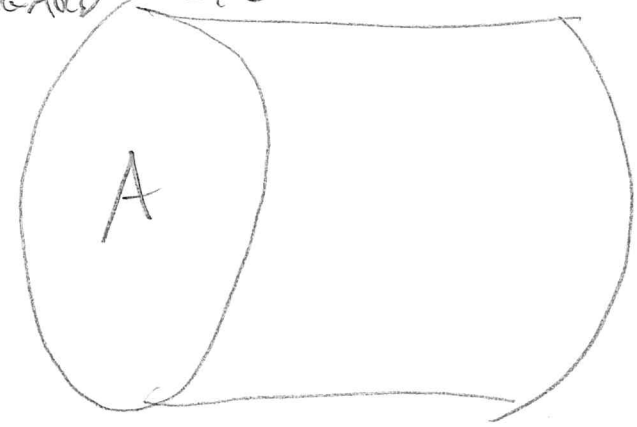
2.3 MECHANICS OF WIND

FOUR MAIN FORCES

a) PRESSURE DIFFERENCES
b) CORIOLIS FORCE
c) CENTRIFUGAL FORCES
d) FRICTION

a) PRESSURE GRADIENT

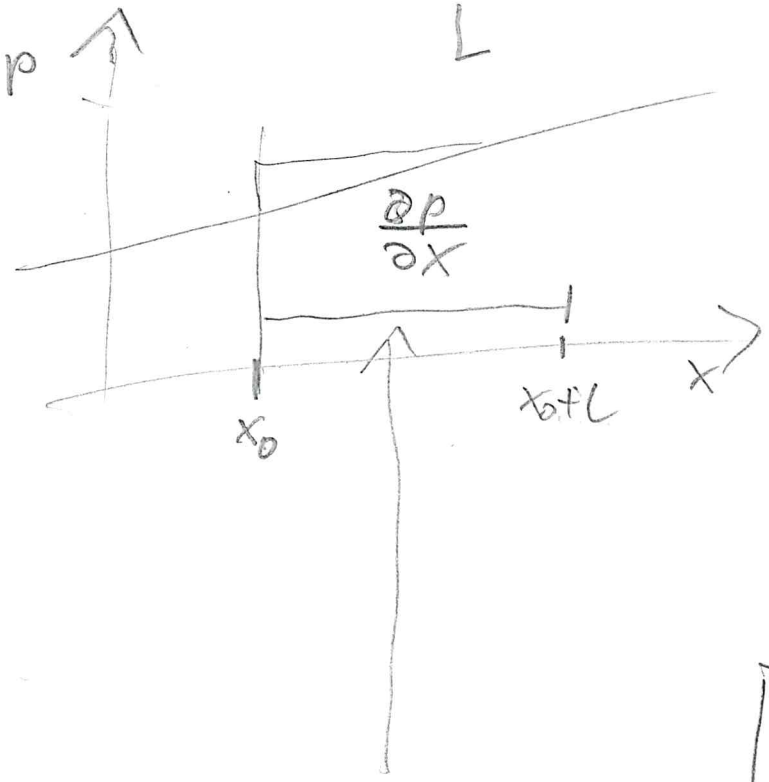
REGARD CYLINDER WITH LENGTH L & AREA A



VOLUME = $L \cdot A$

MASS = $m = \rho \cdot L \cdot A$

(LATER, SHRINK L & A TO ZERO)



PRESSURE VARIES IN SPACE (& TIME)

$p(x,t)$

p UNIT: $Pa = \frac{N}{m^2}$ "Pascal"

(1 millibar = 1 hekto Pascal)

STANDARD ATMOSPHERIC PRESSURE:

101.325 kPa

HERE: 1D PRESSURE GRADIENT

FORCE ON LEFT SIDE: MINUS FORCE ON RIGHT SIDE:

$$F = p(x_0) \cdot A - p(x_0+L) \cdot A$$

$$\approx p(x_0) \cdot A - \left(p(x_0) + L \cdot \frac{\partial p}{\partial x}(x_0)\right) \cdot A$$

$$\frac{F}{V} = p(x_0) A - p(x_0) \cdot A - L \cdot \frac{\partial p}{\partial x}(x_0) \cdot A = -L \frac{\partial p}{\partial x} \cdot A$$

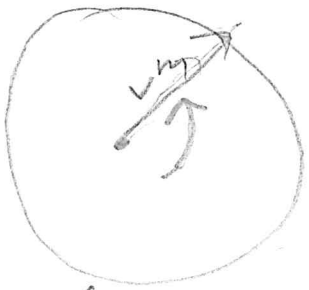
ACCELERATION DUE TO PRESSURE GRADIENT:

$$a = \frac{F}{m} = \frac{-\frac{\partial p}{\partial x} L \cdot A}{\rho \cdot L \cdot A} = \boxed{\frac{-\frac{\partial p}{\partial x}}{\rho}}$$

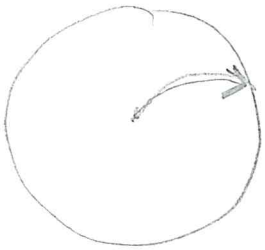
UNIT CHECK: $\left[\frac{N}{m^3}\right] / \left[\frac{kg}{m^3}\right] = \left[\frac{N}{kg}\right] = \frac{kg\ m\ s^{-2}}{kg} = \frac{m}{s^2}$

b) CORIOLIS FORCE

REGARD EARTH NORTHOF NORTH POLE:



$$\omega_0 = \frac{2\pi}{24 \cdot 3600\ s}$$



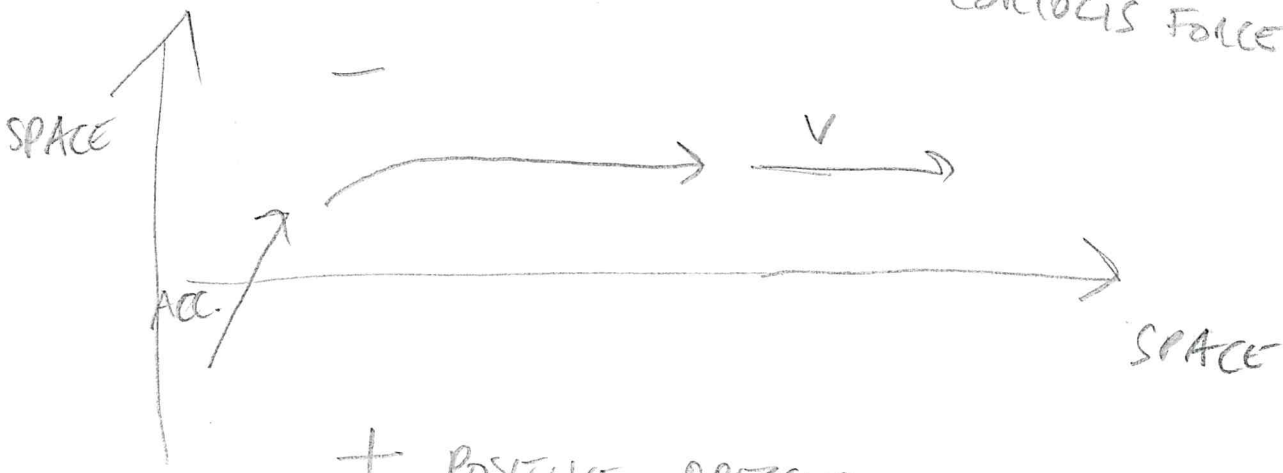
CORIOLIS:
STRAIGHT MOTION OF BODY GETS "ACCELERATED" TO RIGHT IN MOVING EARTH SYSTEM (VIRTUAL FORCE / ACCELERATION).

$$\boxed{a = 2 \cdot \omega_0 \cdot v} \quad \text{OR} \quad \boxed{F = 2m \cdot \omega_0 \cdot v}$$

ON EQUATOR, NO CORIOLIS FORCE, IT DEPENDS ON LATITUDE ϕ

$$\boxed{a = 2 \cdot \sin \omega_0 \cdot v}$$

EFFECT OF PRESSURE GRADIENT & CORIOLIS FORCE



$$\frac{-\frac{\partial p}{\partial x}}{\rho} = 2 \cdot \sin\phi \, \omega_0 \cdot V$$

$$\hookrightarrow \quad V = \frac{-\frac{\partial p}{\partial x}}{2\rho \cdot \sin\phi \cdot \omega_0}$$

"GEOSTROPHIC WIND"
PROP. TO PRESSURE GRAD.
BUT PERPENDICULAR TO ISOBARS !

CF. WEATHER MAPS: