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AC03: Using History to Take the Mystery Out of Units

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Why use history in teaching units?

- Physics units - tricky for US students. Different from "homely and familiar" units.

- Early assignment – review of units & conversions – history of units in context of practice with unit conversion

- History – practical origin of traditional units, PLUS attraction of the arcane!

- Student difficulty in unit conversion revealed math issues – "google-ization" of knowledge changed that, but history still interesting.

- Start with units in US system – convert within US system & between US and SI systems – develop sense of scale from personal values of units

Length: foot, cubit, yard, fathom, hand, inch

- Foot – measure shod ~ 12 inches converts to 30.48 cm exactly ~ 30 cm

- Cubit - "the elbow (cubitum)" various definitions ~1.5 ft -convenient for construction - local standards back to ancient Egypt *[45cm]*

- Yard - stick or rod - nose to fingertipss - convenient for cloth. Standardized in England at various times: Henry I c. 1100, Edward I c. 1300, Elizabeth I in 1588. Standard yard 3 ft, ~ 90 cm *[85 cm]*

- Fathom - span of outstretched arms - defined as 6 ft ~1.8 m. Nautical origin - measure of depth from use of lead line. *[5.5 ft 1.7 m]*

- Hand – 4 inches ~ 10 cm – still used for horses

- inch – once defined as 3 barley corns placed end to end *[~1 finger joint]*

- Since late 1800's   1 inch = 2.54 cm exactly.

It's not just a good idea - It's the LAW!

Distance: miles

- Origin of mile - Latin *mille passum* - 1 000 roman paces

- Roman pace is double pace - i.e. left foot to left foot. Pace ~ 5 feet *[4.5 ft]*

- Roman mile = 5 000 ft ~ 1500 m
  [Morse mile ~1400m]

- 1593 – Replaced by statute mile in England to regularize land measure

Length & Area: rod, furlong, acre, hectare

Furlong - length of furrow plowed by ox team
1 furlong = 40 Rods = 220 yards = 660 ft
Rod = 5.5 yards = 16.5 ft

1 furlong

4 Rods
66 ft

1 acre = 1 furlong x 4 rods =
160 square rods = 43560 sq ft

US high school football field (no end zones)
100 yards x 53.33 yards = 48 000 sq ft
=1.1 acres

US high school soccer field
110 yards x 65 yards = 64350 sq ft
=~1.5 acres

1 are = 10 m x 10 m
1 hectare = 100 are = 10 000 sq m
1 ha = 2.471 acre

football field with end zones = 0.53 ha
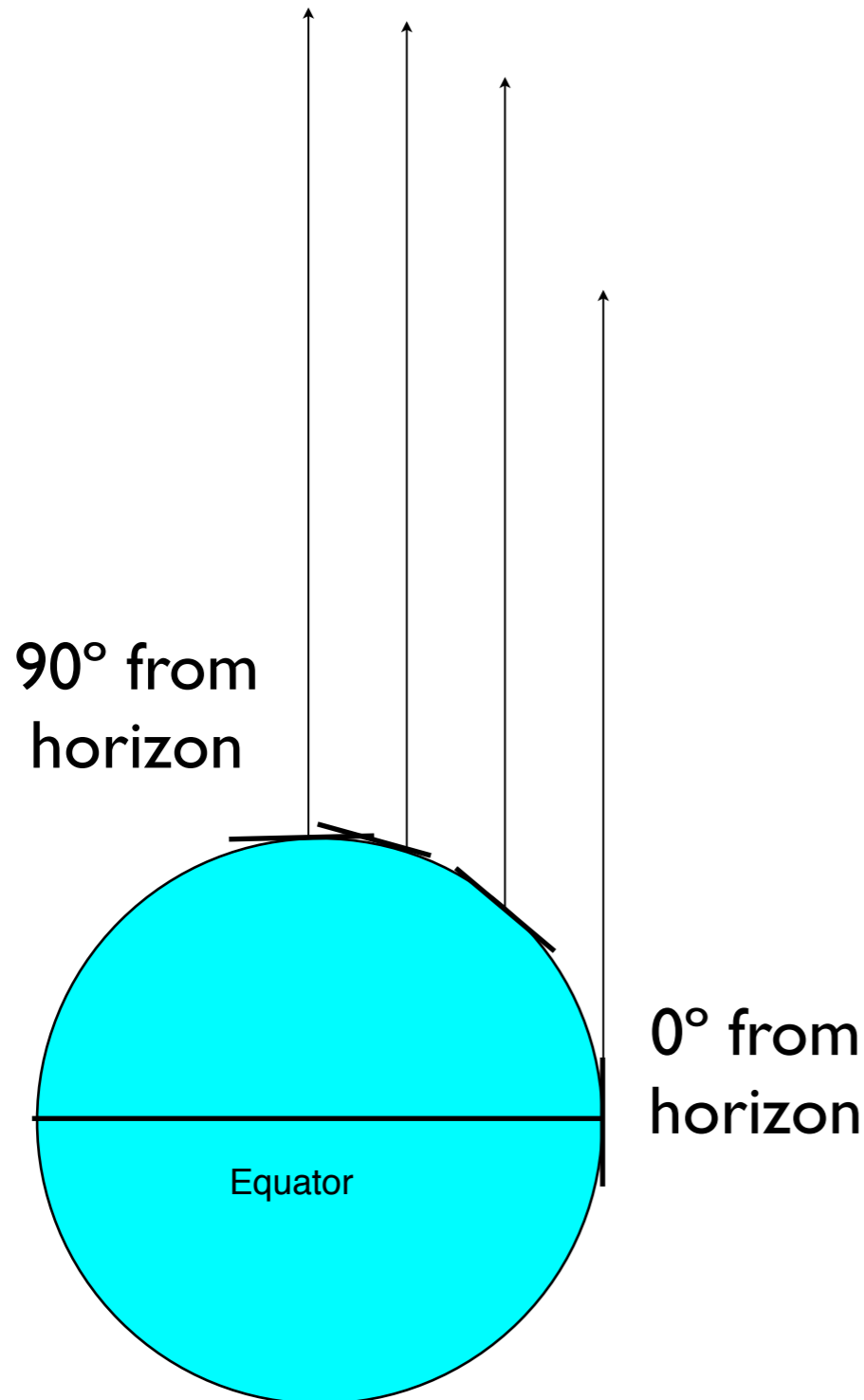soccer field = 0.6 ha
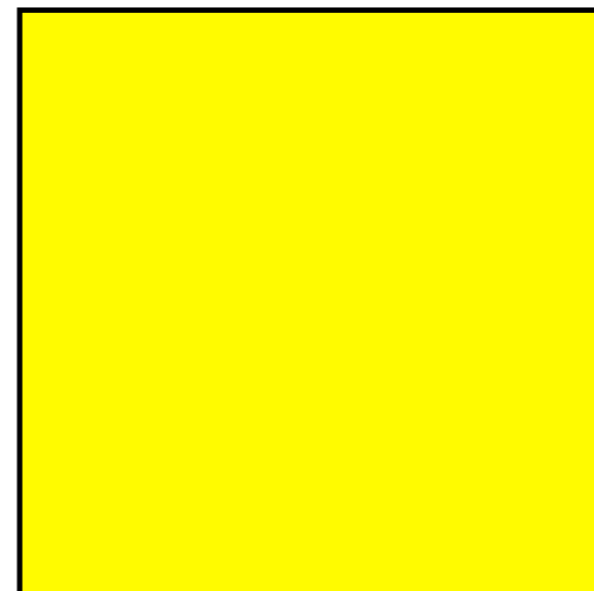
1 hectare

Why the nautical mile?

Astrolabe and
cross-staff

Direction to pole star

90° of 60 minutes = 5400 minutes of arc.
Define 1 minute of arc as 1 nautical mile.

Equator to pole = 5400 nautical miles
circumference = 21 600 nautical miles
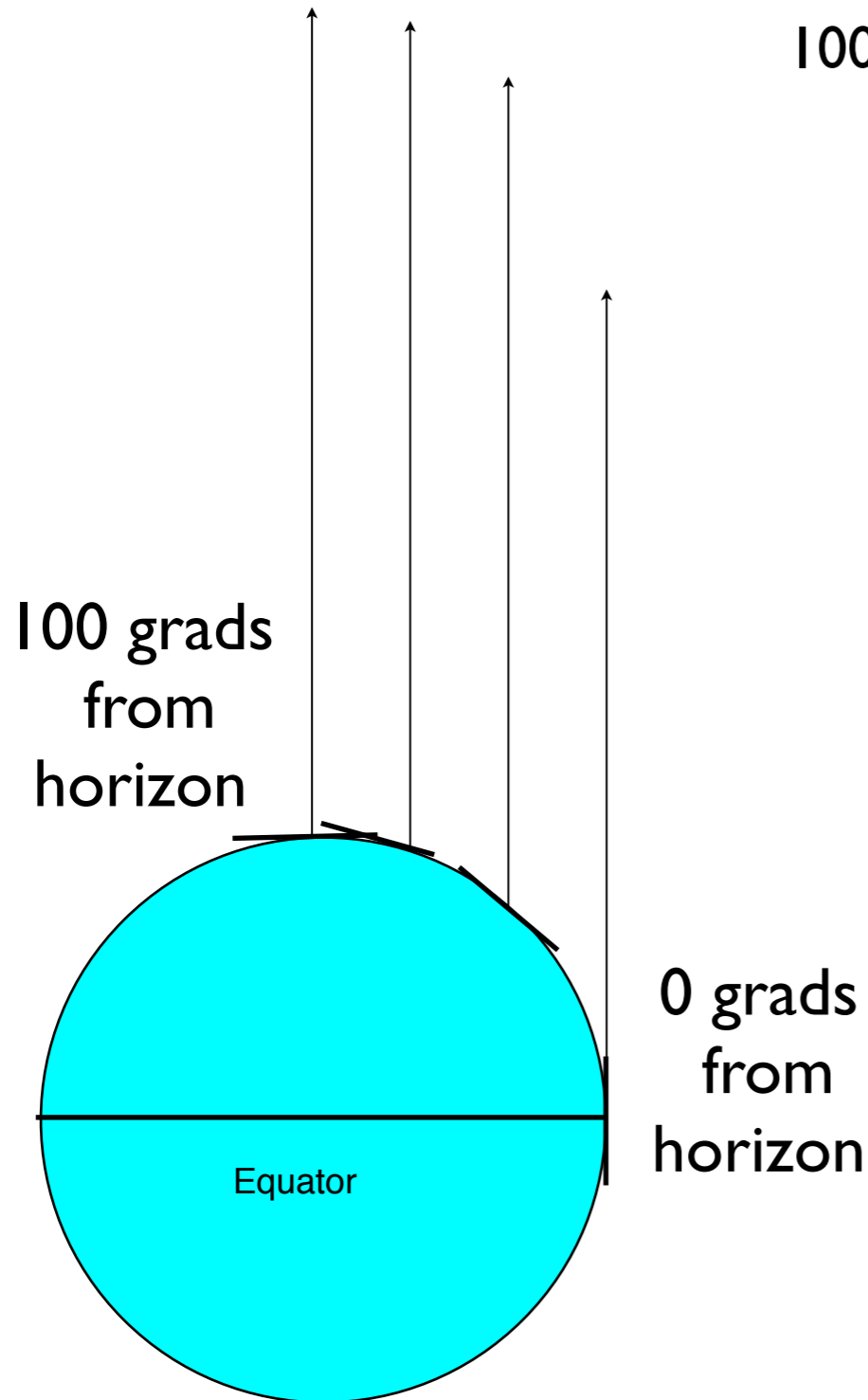
90° from
horizon

1 Nautical mile = 6076 ft
1.15 statute miles

A few early measurements of size of 1 nautical mile

Eratosthenes ~250 BC - size of Earth
at Alexandria in Egypt

0° from
horizon

Equator

Al Ma'mun ~830 AD - length of 1 degree of arc
in the desert of modern northern Iraq

Whence the kilometer?

Direction to pole star

SI - new unit of angle

100 grads of 100 centigrads = 10 000 centigrads of arc.
Define 1 centigrad of arc as 1 kilometer

Equator to pole = 10 000 kilometers
circumference = 40 000 kilometers

1 nautical mile = 1852 km

100 grads
from
horizon

0 grads
from
horizon

Equator

Results?

Some students enjoyed the "romp through the units"

Many later knew how the kilometer was arrived at

Some internalized their personal units

For some it was water off a duck's back

Occasionally a student picked up on the notion of exploring units and history and would bring back a few discoveries of their own

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Some Sources

Lynn White, Jr. , Medieval Technology and Social Change
Andro Linklater, Measuring America
Jim Al-Khalili, The House of Wisdom
various Wikipedia articles on many topics

What about the ark?

- And this [is the fashion] which thou shalt make it [of]:
The length of the ark [shall be] three hundred cubits, the breadth of it fifty cubits, and the height of it thirty cubits.

300 cubits x 50 cubits x 30 cubits
150 yds x 25 yds x 15 yds

Ark top view 0.77 acre
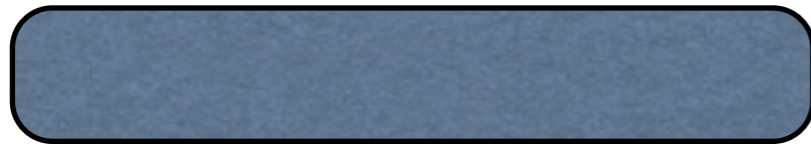
medieval 1 acre field

Ark side view

This page is an Easter Egg - not enough time to include it in talk - since ark measured in cubits, I wanted to compare it in size to an acre, and to a modern ship. The ark we see depicted in medieval art does not look well proportioned, but the dimensions as given are the similar - except in length - to those of the famous S.S. Edmund Fitzgerald - a great lakes bulk carrier

Edmund Fitzgerald
243 yds x 25 yds x13 yds