ANNOUNCEMENTS

- HOMEWORK #4 and (for extra credit) #5 DUE TODAY
- HOMEWORKS #4 & #5 HAVE MATERIAL RELEVANT TO MIDTERM EXAM. WE WILL POST SOLUTIONS ON THURSDAY FOR STUDY and so WE WILL NOT ACCEPT LATE HOMEWORK FOR CREDIT.
- Antikythera Mechanism public show tonight and tomorrow 7pm here
- Midterm exam NEXT TUESDAY in class in BESC 180; i.e. TUESDAY, OCTOBER 13th 2-3:15pm. ***** ONE SHEET OF NOTES AND CALCULATOR ALLOWED ***
- EXAM REVIEW 3—4:45pm MONDAY OCT 12th in Duane D142.
- OPTIONAL SBO OBSERVING next Monday night at 7:30 pm; weather permitting
- ECLIPSE AND ECLIPSE PREDICTION CONTINUES Today by following ancient records...THEN to show that here in North America there is an ancient “eclipse computer” to rival Stonehenge MADE BY NATIVE AMERICANS!
ECLIPSE NUMEROLOGY:

1. **ECLIPSE “SEASONS”** (separated by ½ Draconic period of Sun) = 173 DAYS
   - ECLIPSES ARE POSSIBLE TO happen twice per year when Full and/or New Moon occurs in or near the Lunar Nodes. More solar than lunar eclipses globally (Earth is bigger target for a shadow than the Moon)

   ➤ CAN BE TRACKED USING LUNAR STANDSTILLS!

2. But eclipses do NOT happen on a 173 day interval because all eclipses have to happen at NEW (Solar eclipse) or Full MOON (Lunar eclipse).
   - **ECLIPSE INTERVALS:**
     - 148 days (5 “Moonths”), 163 days (5½ “Moonths”) or 177/178 days (6 “Moonths”).

   ➤ CAN BE TRACKED USING WRITTEN RECORDS… e.g., DRESDEN CODEX OF THE MAYA

3. **LONGER ECLIPSE CYCLES.** The pattern of eclipse intervals repeats exactly over a much longer period (e.g., ~ 33 years in Dresden Codex). Eclipses separated by these longer eclipse periods are closely related; i.e., similar types of eclipses (total >> total, annular ..annular)
ANNULAR ECLIPSE observed here in MAY, 2010 is a member of SAROS ECLIPSE SERIES #128 WHICH STARTED WITH A PARTIAL ECLIPSE ON NOV 16, 1705 ...

AND WILL CONCLUDE WITH A PARTIAL ECLIPSE ON NOV 1st 2282.
Ascending and descending nodes

LUNAR STANDSTILLS OCCUR HERE

KNOWLEDGE OF STANDSTILLS ➔ PREDICTION OF ECLIPSES?
ANCESTRAL PUEBLO ASTRONOMY:

The SUNDAGGER.

An AMERICAN STONEHENGE
Chaco Canyon
ANCIENT PUEBLO ASTRONOMERS: CHACO CANYON

[Map of New Mexico with places marked: Chaco, Acoma, Zuni, Hopi, Rio Grande Pueblos, Denver]
“Great North Road”

John Stein, Mike Marshall, Earl Morris, Anna Sofaer, Pierre Morenon et alia
Aztec
1110-1275

Chimney Rock

Chaco
850-1125

Paquime
1250-1450
FAJADA BUTTE
NOW OFF-LIMITS TO CLIMBERS

SUNDAGGER
“OBSERVATORY”

VIDEO #1
ONE LARGE AND ONE SMALL
“PETROGLYPH”…

CARVING IN THE STONE

(AS OPPOSED TO
“PICTOGRAPH”, A PAINTING
ON THE STONE)
THE SUNDAGGER EFFECT

NEAR NOON ON THE SUMMER SOLSTICE
'SUN DAGGER'  
YEARLY CYCLE  
Chaco Canyon, New Mexico
SUNDAGGER ALIGNMENTS WITH THE SEASONS...MARKS SUMMER AND WINTER SOLSTICES. SMALLER SPIRAL MARKS THE EQUINOXES.

FULL MOON AT LUNAR STANDSTILLS ALSO MARKED USING SHADOWS

ECLIPSE PREDICTION ??
MOON SHADOWS FROM EDGE OF RIGHT-HAND STONE CAST ONTO SPIRAL PETROGLYPH CHART THE LUNAR STANDSTILLS (called maximum and minimum extremes in the movie)

VERY FLAT EASTERN HORIZON ALLOWS ACCURATE LOCATION OF FULLMOON RISE... WHICH CHANGES VERY SLIGHTLY OVER A 19 YEAR SPAN
SUNDAGGER ALIGNMENTS WITH THE SEASONS...MARKS SUMMER AND WINTER SOLSTICES. SMALLER SPIRAL MARKS THE EQUINOXES.

FULL MOON AT LUNAR STANDSTILLS ALSO MARKED USING SHADOWS

➔ ECLIPSE PREDICTION POSSIBLE!

➔ VIDEO #2 clip #2
At solid line in center, full moon is on the ecliptic and an eclipse occurs, once every $9\frac{1}{2}$ years an eclipse occurs for the full moon nearest the solstice (alters between summer and winter).
SHADOW OF THE MIDWINTER FULL MOON RISING CASTS SHADOW ACROSS THE SPIRAL PETROGLYPH.

EACH SUCCESSIVE YEAR THIS MIDWINTER FULL MOON SHIFTS A TINY AMOUNT ON THE EASTERN HORIZON, MOVING SHADOW ACROSS ONE TURN OF SPIRAL EACH YEAR.
SUMMARY ON SUNDAGGER: AN AMERICAN STONEHENGE

- While not specifically dated, the SUNDAGGER likely was constructed ~ 1000 years ago by Ancestral Pueblo Indians.

- Using light and shadows to mark the Solstices, Equinoxes as well, and most importantly for eclipse prediction, the Lunar Standstills !!!

- 9 ½ turns on the spiral rock carving (called a “petroglyph”) is further evidence that Lunar Standstills were tracked ...being half the node cycle.

- While compelling evidence for tracking Solar and Lunar cycles, it is not possible to conclude that Chacoans predicted eclipses, although they HAD THE TOOLS.

- Evidence of tracking Lunar Standstills also found at Chimney Rock in Southern Colorado and in building alignments at Chaco.
CHIMNEY ROCK IN SOUTHWESTERN COLORADO
FULL MOON AT **MAJOR LUNAR STANDSTILL** AS VIEWED FROM Chimney Rock Pueblo

**CHIMNEY ROCK JUST RECENTLY DESIGNATED AS NATIONAL MONUMENT** by President Obama USING the **ANTIQUITIES ACT OF 1906** (Theodore Roosevelt’s doing)
The Development of Eclipse Prediction

STONEHENGE (c. 3000 BCE) in SW England has standing stone alignments with solstices and lunar standstills. Counting device of 56 chalk filled holes marks the lunar node cycle.

The SUNDAGGER (c. 1000 CE) on top of a high butte in Chaco Canyon, New Mexico has light play on a petroglyph (rock carving) which marks the solstices and lunar standstills. A 9 turn spiral marks the node cycle.

WRITTEN RECORD KEEPING COMMENCES !!!

Babylonian astronomer/astrologers record many centuries of eclipses and discover what is known today as the “Saros Cycle” of eclipses.

The Dresden Codex (c. 1100 CE) is a Maya “codex” or bark book which includes an eclipse prediction table.

Culminating in ancient times with a precision gear-wheeled “analog computer” for eclipse prediction: THE ANTIKYTHERA MECHANISM (c. 200 BCE) discovered in a shipwreck off the coast of Greece and is an ancient geared device that was used to predict eclipses by replicating a Babylonian eclipse cycle called the Saros which accounts for the cycles of Sun, Moon and nodes.
# Longer Eclipse Cycles

(EVEN NUMBERS OF SYNODIC & DRACONIC MONTHS)

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Adapted from (see) Chadwick, Margarettt, 1953.
...But even without digital computers, some Greeks could predict eclipses using a geared device, an "analog computer", that tracked the Saros Cycle.