Earth Science Regents

Name _____

Period _____

THE EARTH IN SPACE – *ASTRONOMY NOTEPACKET #1*

Terminology - Frame of Reference - a fixed background against which motions can be measured

Celestial Object - any object outside the Earth's atmosphere - stars are the common

Topics 1&2 pp. 377-378 TQ's p. 381 1abc, 2abc, not d

A. Most stars appear to move across the sky at 15 degrees per hour from east to west in the shape or form of an arc - called celestial daily motion

1. This apparent motion is due to the daily motion of the Earth - the Earth turns at 15 degrees an hour from west to east - this is called terrestrial daily motion
2. Terrestrial daily motion causes celestial daily motion
3. Most stars appear to circle around Polaris because it's located directly above the Earth's axis of rotation - these are called circumpolar stars p.377 21.1
4. Stars rise in the east, set in the west, circle around Polaris in the north, and move in large, arc shaped paths in the south

Topics 8&9 pp. 403-404 TQ's p. 404 8a, not b, 9abcd

B. The movements of planets across the nighttime sky is not uniform

1. The reason planets have non-uniform motion is that they really are moving in space - stars only look like they're moving
2. Planets rotate while they revolve
    a. we know this because features on the planets surface vary in a predictable manner
3. The angular diameter of planets vary in a cyclic manner due to their eccentric orbits

C. There are two ways to account for observed celestial motions:

1. Geocentric Model - one where celestial objects revolve around a stationary Earth - an Earth centered model

a. model was the product of Ptolemy - celestial objects revolved westward around the Earth
b. outer planets moved on an epicycle while the epicycle followed a deferent
c. it does explain what you see in the nighttime sky - it could be correct
d. it does NOT account for terrestrial motions and phenomenon like the Foucault Pendulum and the Coriolis effect
e. it's an extremely complicated model whereas there is a simpler model which explains more

2. Heliocentric Model - one where the Earth rotates on its axis while revolving around the Sun - a Sun centered model
   a. model was the product of Copernicus - celestial objects revolved eastward (counterclockwise) around the Sun
   b. it does explain what you see in the nighttime sky - it could be correct
   c. it DOES account for terrestrial motions and phenomenon like the Foucault Pendulum and the Coriolis effect
   d. it's a much simpler model which explains more things

D. The natural state of all objects is motion - all things are moving all the time
   1. The Earth has 3 primary motions Topics 1,2,3, 4 pp. 457-459 TQ's p. 460 1abcde, 2abc, 3ab, 4abcd
   2. Rotation - the Earth turns on its axis from west to east at 15°per hour also known as terrestrial daily motion - how do we know?:
      a. Foucault/Free swinging Pendulum - it <u>appears</u> to change it's direction of swing in a regular manner - it shouldn't do this - it's really the room turning underneath an unchanging swing p. 458 25.3
      b. Coriolis Effect - objects moving across the surface of the Earth <u>appear</u> to travel in curved paths - it's an illusion caused by the

surface of the Earth turning

1) it's is observable in winds, ocean currents, long-range cannon shells, and rockets' paths
2) objects appear to curve to their right in the northern hemi-spere and to their left in the southern hemisphere

c. star trails - either stars really do move at l5° per hour or we do
d. day and night - either the Sun revolves around the Earth or we turn on our axis

The rotational velocity of the Earth varies with latitude - it's greatest at the equator (1000mph) and least at the poles (0mph)

3. Revolution - the Earth's motion around the Sun - how do we know?: Topics 9,10 pp. 465-466 TQ's p. 466 9ab, 10ab,

a. Doppler Effect - the distortion of a wave form caused by motions
1) as the Earth moves towards stars, their light waves are compressed and shift to a shorter wavelength
2) as the Earth moves away from stars, their light waves are stretched and shift to a longer wavelength

b. Star shift - the stars <u>appear</u> to change position about 1° per night relative to a fixed position on the Earth's surface
1) there are 360° in a circle, it takes about 360 days to orbit the Sun, so there's the 1° shift
2) it is revolution that accounts for us seeing different constellations during different seasons of the year - since we are moving in space, we have different views at different times p. 378 21.3

4. Precession - the Earth's axis of rotation "wobbles" back and forth in space

a. one wobble takes 26000 years - it's not noticeable in a lifetime

b. precession means that Polaris will not always be located directly above the North Pole - as time passes, the axis of rotation will point to different areas of space

E. The Seasons and Earth-Sun Relationships Topics 11,12,13,14,15,16 pp. 466-469

TQ's p. 466 11abcd p. 469 12abcd, 13abcd, 14abcd, 15abc, 16ab

The seasons are the result of 3 factors:

1. Inclination of the axis of rotation - 23.5° from the vertical
2. Revolution around the Sun
3. Parallelism - the Earth's axis of rotation always points in the same direction in space - NOT relative to the Sun p. 457 25.2

NOTE: all times are local solar time - time based on a sundial p. 469 25.15

to see the Sun at noon, you must face south

1. September 21 - Autumnal Equinox - 1st full day of fall - date varies slightly
   a. the direct rays of the Sun land on the equator at solar noon
   b. everyone on Earth has 12 hours of daylight and 12 hours of darkness
   c. everyone on Earth sees the Sun rise due east and set due west
   d. In New York State, the altitude of the noon Sun is about 48° -average-
   e. at solar noon, shadows point north and are average in length
   f. if you move north, the Sun gets lower at noon but daylight remains at 12 hours
2. December 21 - Winter Solstice - 1st full day of winter - date usually is the 21st
   a. the direct rays of the Sun land on the Tropic of Capricorn at solar noon
   b. in New York State we have about 8 hours of daylight, 16 of darkness
   c. in New York State, Sunrise is most south of east, Sunset most south of west
   d. in New York State, the altitude of the noon Sun is 24.5° - lowest at noon -
   e. at solar noon, shadows point north and are the longest of the year
   f. if you move north, the Sun gets lower and the days get shorter
3. March 21 - Vernal Equinox - 1st full day of spring - the date varies slightly

With the exception of the date and name, all information about this equinox is the same as the Autumnal equinox

4. June 21 - Summer Solstice - 1st full day of summer - date usually is the 21st
    a. the direct rays of the Sun land on the Tropic of Cancer at solar noon
    b. in New York State we have about 16 hours of daylight, 8 of darkness
    c. in New York State, Sunrise most north of east, Sunset most north of west
    d. in New York State, the altitude of the noon Sun is 71.5° - highest at noon -
    e. at solar noon, shadows point north and are the shortest of the year
    f. if you move north, the Sun gets lower and the days get longer

Facts about Earth-Sun relationships:

1. From the winter solstice to the summer solstice the altitude of the noontime Sun increases from 24.5 to 71.5 degrees - winter and spring
2. From the summer solstice to the winter solstice the altitude of the noontime Sun decreases from 71.5 to 24.4 degrees - summer and fall
3. During spring and summer, the Sun rises north of east and sets north of west - this is most pronounced on June 21st
4. During fall and winter, the Sun rises south of east and sets south of west - this is most pronounced on December 21st
5. During winter and spring, the days get longer - during summer and fall, the days get shorter
6. The direct rays of the Sun cover 47° of latitude, from 23.5 north on June 21st to 23.5 south on December 21st
7. The direct rays of the Sun do NOT impact the continental United States - the Sun is NEVER directly overhead at any location in the continental United States

F. Orbit - the path a planet takes as it revolves around the Sun - it's a balance between gravity and inertia
    1. Kepler's Laws of Planetary Motion: Topic 11 pp. 405-406 TQ's

p. 407 11abcd

a. all planets orbit the Sun in elliptical paths with the Sun at one foci
b. over equal amounts of time, planets sweep out equal areas of space
p. 405 22.10
c. a planets period of revolution is directly related to its distance from the Sun - the further a planet is from the Sun, the longer it takes to go around the Sun

2. Orbit terminology
   a. ellipse - a closed line with two "centers" called foci
   b. eccentricity - a measure of how out of round an orbit is
      1) E=D/L where D is the distance between foci and L is the major axis
      2) values range from .000 (a circle) to .999 (a straight line)
      3) the greater the value, the more out of round the shape
   c. major axis - the longest straight line you can draw inside the orbit - the line must pass through the foci
   d. perihelion - the day the Earth and Sun are closest together-January 3rd
      1) the Earth has its greatest orbital velocity - maximum kinetic energy
      2) the Earth has its least potential energy
      3) the Sun looks largest because we're closest to it
   e. aphelion - the day the Earth and Sun are furthest apart- July 4th
      1) the Earth has its lowest orbital velocity - minimum kinetic energy
      2) the Earth has it most potential energy - the farthest to "fall"
      3) the Sun looks smallest because we're farthest away
   f. orbital velocity - the speed at which a planet orbits the Sun
      1) from perihelion to aphelion, orbital velocity decreases
      2) from aphelion to perihelion, orbital velocity increases
   g. retrograde motion - the <u>apparent</u> "backing up"" of a planet in its orbit around the Sun Topic 8 pp. 403-404 TQ p.404 8b
p. 404 22.8

1) it occurs whenever a slower moving planet is passed by a faster moving planet in their orbit around the Sun
2) as viewed from Earth, the outer planets retrograde
3) it's an optical illusion explained by a heliocentric model
4) in a geocentric model, epicycles and deferents are required

h. Angular Diameter - the angle formed between the sides of an object and your eye.
   1) it depends on distance between the object and the viewer - indirectly
   2) and the true size of the object - directly

G. Time and Earth Motions Topics 5,6,7,8 pp. 461-464 TQ's p. 464 5abc, 6abc not d 7ab, 8abc

1. Time is based on the apparent motion of the Sun across the sky - this means time is based on rotation
2. Local Solar Time - time based on a sundial or shadow stick - not clock time
3. Local Solar Noon - the moment when the Sun is highest in the sky for that day - usually not 12 noon, clock time
4. Midnight - 180 degrees of longitude from local solar noon
5. Greenwich Mean Time - the time on the Prime Meridian - used to calculate longitude
6. Standard Time Zones - 15 degree wide belts of longitude wherein all people have the same **clock** time - not the same solar time p. 462 25.7
   a. when you travel east, you add time
   b. when you travel west, you subtract time
   c. 15° of longitude = one hour of solar time
   d. moving north or south has NO EFFECT on time
   e. all points on a single meridian have the same:

1) local solar noon
2) local solar time
3) standard time (clock time)

7. Apparent Solar Day - the amount of time it takes the Earth to rotate from local solar noon one day to local solar noon the next day - + or - 24 hours, it varies with the seasons
8. Mean Solar Day - the average of all the apparent solar days - it's exactly 24 hours long

H. Moon Motions and Phases Topics 14,15,16,17 pp. 444-446 TQ's p. 448 14abcd, 16abcd, 17ab

1. Perigee - the day the Earth and Moon are closest together - the Moon would have its highest orbital velocity and largest angular diameter
2. Apogee - the day the Earth and Moon are furthest apart - the Moon would have its lowest orbital velocity and smallest angular diameter
3. Sidereal Month - the amount of time it takes the Moon to revolve around a stationary Earth - 27.3 days - associated with geocentic model
4. Synodic Month - the amount of time it takes the Moon to complete a cycle of phases - 29.5 days - associated with a heliocentric model
   a. it is 2 days longer because it takes the Moon a total of about 48 hours a month to "catch up" to an Earth which is revolving around the Sun p. 446 24.14
   b. the Moon's period of rotation is the same as its period of revolution - therefore the same side of the Moon always faces the Earth
5. Phase - the amount of lighted surface visible from the Earth
   a. phases are caused by the Moons revolution around the Earth
   b. the angle between the Sun, Earth, and Moon change from night to night - the angle between the 3 determines what phase we see
   c. the phases repeat themselves in a cyclic, predictable manner
   d. the angular diameter of the Moon's phases varies in a cyclic,

predictable manner

e. waxing phases - to see more lighted surface than you saw the night before - new to full

f. waning phases - to see less lighted surface than you saw the night before - full to new

There are 8 basic Moon phases: p. 445 24.13

1. New Phase - Sun, Moon, and Earth all line up in this order - 1 per month
2. Waxing Crescent - Sun, Earth, and Moon meet in space at an acute angle - more than 1 per month
3. Waxing Quarter - Sun, Earth, and Moon meet in space at a right angle- 1 per month
4. Waxing Gibbous - Sun, Earth, and Moon meet in space at an obtuse angle - more than 1 per month
5. Full Phase - Sun, Earth, and Moon all line up in this order - 1 per month p. 444 24.12
   a. since the Moons orbital plane is inclined to the Earth's orbital plane by 5°, a lunar eclipse doesn't happen each month
6. Waning Gibbous - Sun, Earth, and Moon meet in space at an obtuse angle - more than 1 per month
7. Waning Quarter - Sun, Earth, and Moon meet in space at a right angle - 1 per month
8. Waning Crescent - Sun, Earth, and Moon meet in space at an acute angle - more than 1 per month

I. Eclipses - when the shadow of one celestial object is cast on to the surface of another celestial object Topics 18, 19 pp. 446-448 TQ's p. 448 18bcd not a, 19bc not ade

1. Lunar Eclipse - when the shadow of the Earth is cast on to the surface of the Moon
   a. it's a curved shadow - evidence for a round Earth shape
   b. everyone on the nighttime side of the Earth can see such an eclipse
   c. fairly common and safe to view

2. Solar Eclipse - when the shadow of the Moon is cast on to the surface of the Earth
    a. it's a much smaller shadow since the Moon is much smaller than the Earth
    b. you must be at the right spot at the right time to see such an eclipse - not everyone on Earth can see it and others see it at a different time
    c. they are rare and dangerous to view

J. Tides and Celestial Motion Topics 20,21,22,23 pp. 449-451 TQ's p. 451
20bcd not a, 21ab, 22abc, 23cd not ab

1. Tides - the rhythmic rise and fall of sea level
2. There are 2 high tides and 2 low tides every 24 hours -roughly -
    a. one high tide (direct high tide) is caused by the Moon's gravitational pull on the ocean on the side of the Earth facing the Moon
    b. one high tide (indirect high tide) is caused by the Moon's gravitational pull on the center of the Earth, pulling the Earth away from the ocean on the side opposite that facing the Moon
    c. low tides are caused by water rushing to the 2 high tides
    d. spring tides - unusually high highs or low lows - occur when the Moon is either full or new
    e. neap tides - unusually low highs or high lows - occur when the Moon is in a quarter phase
    f. barycenter - the common point of balance between the Earth and Moon -1700 Km inside the Earth
        1) it is the barycenter that orbits the sun - the Earth and Moon are a binary system

K. Gravitation - the mutual attractive force that exists between all objects in the universe Topic 13 pp. 406-407 TQ p.407 13ab

"The force of gravity between two objects is directly proportional to their masses and inversely proportional to the square of the distance separating the centers of their masses"

1. If the mass of one or both objects increases while the distance between them remains constant, the force of gravity between them increases

2. If the mass of one or both objects decreases while the distance between them remains constant, the force of gravity between them decreases
3. If the distance between the objects increases, while their masses remain constant, the force of gravity between them decreases
    a. twice as far apart = $1/4^{th}$ the gravity
    b. three times farther apart = $1/9^{th}$ the gravity
    c. four times farther apart = $1/16^{th}$ the gravity
4. If the distance between the objects decreases, while their masses remain constant, the force of gravity between them increases
    a. twice as close together = 4 times the gravity
    b. three times closer together = 9 times the gravity
    c. four times closer together = 16 times the gravity