Homework 1 (Before Midterm)

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1 Homework Chapter 1

1.1 Summary and Self Test

1. In increasing size, the following goes: Earth, Sun, Solar System, Milky Way Galaxy, Local Group, Virgo Supercluster, Universe.

2. **(c)** If we compare our place in the universe with a very distant place, all of the laws of physics are the same in each place. This is important because, otherwise, our observations and ideas about the universe would be much less useful if they only explained what happened on Earth.

6. In order of size, the following goes: radius of the Earth, a light minute, the distance from the Earth to the Sun, a light hour, the radius of the Solar System, and then a light year.

8. **(b, d, a, c, e)**

   (a) Hydrogen and helium are made in the big bang. This must happen first so that the Sun can be made.

   (b) Stars are born and process light elements into heavier ones. These stars form from the elements in the previous step and allow for the creation of heavier elements which are involved in the following steps.

   (c) Stars die and distribute heavy elements into the space between the stars. The exploding stars move the elements around space.

   (d) Enriched dust and gas gather into clouds in interstellar space. The stuff that comes out of the previous step collects together for the next step to happen.

   (e) The Sun and planets form from a cloud of interstellar dust and gas. Finally the components from the previous steps lead to the creation of the Sun and planets.

1.2 True/False and Multiple Choice

19. **(d)** The Big Bang created hydrogen, helium and lithium, but not carbon.

21. **(c)** Occam's razor states that if two hypotheses fit the facts equally well, choose the simpler one.

22. **(a)** The cosmological principle states that on a large scale, the universe is the same anywhere at a given time.

1.3 Conceptual Questions and Problems

30. When a star explodes in the Andromeda Galaxy, it takes 2.5 million years for us to see it on Earth since it is 2.5 million light years away.

31. When scientists say we are made of stardust, they mean that we are made of elements that form stars and come from the explosion of stars. The Big Bang created only hydrogen, helium, and small amounts of lithium. Heavier elements that we are made of come from in the centers of stars or in supernova explosions.

32. Falsifiable means that something can be proved false by experimental or observational evidence. Saying that there is an afterlife isn't falsifiable because theres no way to know whether there is or isn't one unless you die. Saying "you can live without food or water," however, *is* falsifiable because you can do experiments to see if the hypothesis is false.

33. In common language, "theory" is used as another word for guess. Scientists, however, use "theory" to explain something based on observations and data that has been extensively tested, but never proven wrong (or at least yet).

34. A hypothesis is simply an idea that can be tested and which a prediction can be made on. A theory, however, has been tested extensively with regard to many factors which can be used to explain something.

35. If a discrepancy between scientific fields were found, the two ideas may be tested and modified until the conflict is resolved.

37. The fact that textbooks change shows that our knowledge can morph and change as we learn more. Over time, technology advances, ideas pop up, and this all can create opportunities to improve our understanding of the universe. Our scientific facts then end up evolving as we learn more.

1.4 Problems

43. For this problem, we can assume that the car goes 60mph on average during a trip from New York to Los Angeles. We know that that $d = vt$ with d representing distance, v representing velocity and t representing time. If we solve for time, we get $t = \frac{d}{v}$. Plugging in the numbers, we are left with $t = \frac{2444\text{miles}}{60\text{mph}} = 40.733$ car-hours. Since there are 24 hours in a day, this would be $\frac{40.733}{24} = 1.697$ car-days. For walking, we can assume that walking speed is 3 miles per hour on average. This would mean it would be 20 times longer equaling 814.67 walking-hours or 33.94 foot-months. There are 365 days in a year and 12 months in a yar so this would be 1.116 foot-months or 0.092998 foot-years.

2 Homework Chapter 2

2.1 Summary and Self Test

2. **(a, b, c)** The stars we see at night depend on our location on Earth, Earth's location in its orbit, and the time of the observation. The movement of stars through space is too slow for our eyes to see on Earth.

7. **(b)** If Earth's axis had only a 3° tilt, the seasons would be much less extreme. With a 3 degree tilt, over the course of a year there poles will point towards/away from the sun with only 3 degrees deviating from straight up and down. **(a)**

8. If you see the first quarter Moon overhead on the meridian, the Sun will be on the western horizon. During a first quarter Moon, the sun will be setting when the Moon is on the meridian and the sun sets in the west which means it will be on the western horizon.

10. **(a, b, d)** If the Moon were in the same orbital plane, but twice as far from Earth, total eclipses of the sun would not be possible, and the Moon's cycle would take longer. At the moment where the Moon is barely allows for total eclipses of the sun and sometimes now when the moon is a little further from the Earth the Moon is not large enough to cover the Sun. With twice the diameter of orbit, the period of Moon's orbit would be longer and so the Moon's cycle would take longer. The phases of the moon, however, would be the same since the the moon will still orbit the Earth on the same plane and have one side lit on the moon. Earth's shadow will also still cover the Moon making lunar eclipses still possible.

2.2 Multiple Choice and True/False

16. **(e)** The tilt of Earth's axis causes seasons because the days are longer in the summer and the rays of light strike the ground more directly in the summer.

23. **(d)** If you were standing at Earth's South Pole, you would see no stars rising and setting. On the South Pole, as the Earth rotates, all the stars are circumpolar and no star will go past the horizon and come back.

2.3 Conceptual Questions

29. The zodiacal constellations are associated with the times when that constellation is in the sun which will be during the day and not when the constellation is visible at night. As such, Sagittarius is associated with December where it is not visible because of the sunlight. That is why Sagittarius is visible in the summer and not the winter.

34. The claim that the defendant could not see the pedestrian because the full Moon was casting long shadows across the street at midnight is not credible. At full Moon, the Moon is directly overhead at midnight and so the shadows should be short, not long.

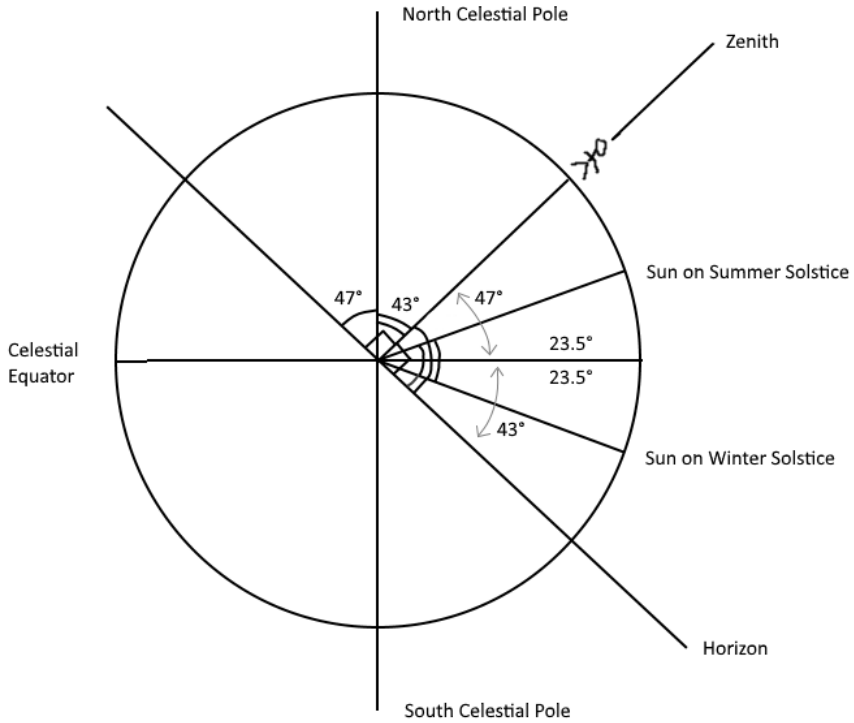
The only exception would be if the defendant was near the Arctic circle where the Moon never gets far up in the sky.

36. We do not see a lunar eclipse each time the Moon is full because the the moon orbits the Earth on a different plane than the ecliptic plane. For there to be a lunar eclipse, there must be a new moon in a position where the planes intersect which happens about twice a year. The same logic applies for a solar eclipse, but is even stricter because of the relative size of the moon and the sun.

40. If you just experienced the longest day of the year in the Northern Hemisphere and the shortest day in the Southern Hemisphere, then you are flying on a solstice around June 21. To explain it to the person next to me I would show them a drawing (fig1)*. Because of the Earth's tilt, certain days happen to be longer or shorter depending on where the Earth is in its orbit. On that day, it happened to be the summer solstice in the Northern Hemisphere which meant it was the longest day of the year and the Earth was in a position where the north side was angled toward the Sun. Since the North side is angled toward the sun, the South side would be angled away and that would mean it would be the shortest day in the Southern Hemisphere.

47. (a) Altitude of North Celestial Pole from our latitude is at 47°, visible in the diagram.

    (b) The angle along the meridian between the celestial equator and the local zenith is 47°, the same as our latitude on Earth. The altitude of the Sun on the winter solstice is $43 - 23.5 = 19.5°$. The altitude of the Sun on the summer solstice is $43 + 23.5 = 66.5°$.



2.4 Seasons Homework

1. (a) Planet Itfellonitsside will not have day and night. Since the axis of rotation is always parallel to the light coming towards it, the rotation will not be moving any areas in or out of sunlight. Additionally, since the axis points towards the sun at all times, there will be no new areas exposed to sunlight as the planet revolves around the sun.

   (b) Planet Itfellonitsside will not have seasons. As the planet revolves around the sun, the rotational axis is always pointed at the Sun. Since north is also always pointed at the sun, the same side will be facing the sun at all times in a year. The northern hemisphere will always be in "summer" and the southern hemisphere will always be in "winter." Relative to the planet, there are no seasonal changes over the course of a year and so there are no seasons.

2. (a) The tilt of the planet is different than the Earth's in that it always points toward the sun. In our Solar System, the Earth's tilt stays oriented roughly the same (toward Polaris), not pointing toward the Sun except once a year.

   (b) Planet Fascinatedbythesun will have day and night, but only for certain parts of the planet. Because of the 23.5° tilt, a section of the middle of the planet will pass through the terminator meaning that there will be day and night in those places.

   (c) Planet Fascinatedbythesun will not have seasons. Since the axis of rotation always points toward the sun, the sun and the planet will essentially be in the same orientation relative to each other at all times. The angle that the light hits the planet will stay the same throughout the course of a year meaning the intensity of light will never change. The length of day and night also remains constant throughout the course of a year. Because of this, there will be no seasonal changes and the planet will not have seasons.

2.5 Moon Phases Homework

Moon Phases homework is attached with edits on the worksheet. There are minimal corrections.

3 Homework Chapter 3

3.1 Summary and Self Test

1. (a) A planet moves fastest when it is closest to the sun and slowest when it is furthest from the Sun.

   (b) Each ellipse has two foci. At one focus is the Sun. At the other focus is nothing.

   (c) A planet with a period of 84 Earth years has an orbit that is larger than a planet with an orbit of 1 Earth year.

6. Eccentricity is how far the foci are apart which corresponds to how flat the ellipse it. The eccentricity of a circular orbit is zero. This would be when both foci are on top of each other.

9. **(a, b, c, d)** A net force must be acting when an object accelerates, an object changes direction but not speed, an object changes speed but not direction, or an object changes speed and direction. This is because net force is required to create any acceleration and acceleration is any change in velocity, meaning any change in direction or speed, including combinations of both.

10. **(a)** If I was transported to a planet with twice the mass of Earth, but the same radius of Earth, my weight would be increased by a factor of 2. Newton's universal law of gravitation says:

$$F_{\text{gravity}} = \frac{Gm_1m_2}{r^2}$$

The thing that changes is the mass of the planet and multiplying that by two will result in two times the force due to gravity.

3.2 Multiple Choice and True/False

23. **(c)** Both forces are the same according to Newton's Third Law. The formula for gravitational force is $\frac{Gm_1m_2}{r^2}$ and this is applied on both objects equally.

25. Since the average distance from Uranus from the Sun is 19 times Earth's distance from the Sun. The Sun's gravitational force on Uranus is 361 times weaker than the sun's gravitational force on Earth. From the formula in the answer to question 23, we can see that the denominator contains an r^2 which means 19 times greater distance will mean $19^2 = 361$ times weaker gravitational force.

3.3 Conceptual Questions

26. The semi-major axis is especially important because the length of it is equal to the average distance of a planet's orbit to the object it is orbiting. Additionally, according to Kepler's third law, this average distance (d) is related to the orbital period (p) in that $p^2 \propto d^2$.

27. Inertia is an object's resistance to a change in motion. The more inertia an object has, the harder it is to accelerate that object. This is related to mass because an object with more mass will have more inertia than an object with less mass.

35. Weight and mass are different because weight is a measurement of force due to gravity while mass is a measurement of the amount of matter inside an object. The mass of an object remains the same regardless of what object it is on or how much gravity it is being subject to. This is different than weight which depends on the object it is on and what forces are acting upon it.

37. A bound orbit is where an object is gravitationally bound to the object it is orbiting. This means that the orbiting object will stay in orbit and will orbit in the shape of an ellipse. An unbound orbit is when an object begins to orbit another object, but reaches a velocity faster than the escape velocity and continue to leave orbit.

39. If astronomers discovered an object approaching the Sun in an unbound orbit, that would mean that the object came from outside the Solar System. If the object was a part of the Solar System, it would be in a bound orbit around the sun. As such, an object approaching in an unbound orbit will have come from outside the Solar System.

3.4 Numerical Problems

41. We can solve the for the period based on distance using Kepler's Third Law.

$$
\begin{aligned}
d^3 &\propto p^2 \\
d_{earth}^3 &\propto p_{earth}^2 \\
d_{obj}^3 &\propto p_{obj}^2 \\
\left(\frac{d_{obj}}{d_{earth}}\right)^3 &= \left(\frac{p_{obj}}{p_{earth}}\right)^2 \qquad \text{(then plug in values)} \\
\left(\frac{46.4 \text{ AU}}{1 \text{ AU}}\right)^3 &= \left(\frac{x \text{ Earth Years}}{1 \text{ Earth Year}}\right)^2 \\
x = 46.5^{3/2} &\approx \boxed{316.1 \text{ Earth Years}}
\end{aligned}
$$

49. (a) Just as you fall out of the airplane your gravitational acceleration would be $9.8 m/s^2$ as that is the approximately the acceleration due to gravity on the surface of Earth. Depending on how high in the air, it could be a bit less.

    (b) This acceleration would be the same as if you were strapped to a flight instructor and had twice the mass. The force due to gravity depends on the mass of the object subject to that gravity, however, the acceleration due to gravity stays constant regardless of mass.

    (c) Just as you fall out of the airplane, the gravitational force on you, assuming your mass is 70kg, would be around 686N. $F = ma$ and so $70kg * 9.8m/s^2 = \boxed{686N}$

(d) The gravitational force would be bigger if you were strapped to a flight instructor and so had twice the mass. Looking at the formula, doubling the mass would double the force as acceleration stays constant. $(2m) * a = 2F$. Additionally, the universal law of gravitation says the same thing. $\frac{G(2m_1)m_2}{r^2} = 2F$.

4 Homework Chapter 4

4.1 Summary and Self Test

5. **(c)** Light acts as both a wave and a particle. In some experiments light is observed to act as a wave, but in others it seems like it acts as a particle.

8. **(a, e)** Radio waves and visible light can be observed from the ground. Higher energy waves like ultraviolet light, x-ray light, and gamma radiation do not pass well through the atmosphere to the ground.

9. **(e, c, b, d, a)** Radio waves have the longest wavelength, followed by infrared radiation, visible light, ultraviolet light, and finally gamma rays.

10. (a) aperture is **(3)** the diameter of the largest lens or mirror of the telescope
    (b) resolution affects the **(4)** ability to distinguish objects that appear close together in the sky
    (c) focal length is **(2)** the distance from lens to focal plane
    (d) chromatic aberration is **(6)** a rainbow-making effect
    (e) diffraction is **(7)** a smearing effect due to sharp edges
    (f) an interferometer is **(1)** several telescopes connected to act as one
    (g) adaptive optics is **(5)** computer-controlled active focusing which helps to correct for the distortion that occurs in Earth's atmosphere

4.2 Multiple Choice and True/False

17. **(d)** Light at the lowest energy end of the electromagnetic spectrum is in the radio region. That region is the area with the longest wavelength and the lowest frequency which correlates with low energy.

20. **(b)** If the wavelength of a beam of light were halved, the frequency would be two times larger. The wave speed of a beam of light stays constant and since $c = f\lambda$, halving the wavelength will result in double the frequency.

24. **(b)** Gamma ray telescopes are placed in space because gamma rays do not penetrate the atmosphere. Gamma rays are capable of destroying atoms in the atmosphere so as they pass through Earth's atmosphere, the energy is dissipated and the rays do not reach the ground.

4.3 Conceptual Questions

28. The energy of a single photon is different than the energy of a beam of light. If photons of blue light have more energy than photons of red light, a beam of red light can carry as much energy as a beam of blue light if the beam of red light has more photons. Since photons of blue light have more energy, less is required to create a beam of the

same energy as that of a red beam, but it is still possible to have beams of equal energy given that the energy and photons are available.

36. One way Earth's atmosphere interferes with astronomical observations is by distorting visible light. As light passes through the atmosphere, the small bubbles of air act like weak lenses which, by the time it might reach the telescope, the image can become fuzzy and distorted. Earth's atmosphere also interferes with astronomical observations by preventing certain wavelengths of electromagnetic radiation from passing through. Higher energy waves like gamma rays, x-rays, and ultraviolet rays do not pass well through the atmosphere and so it becomes more difficult to observe those kinds of radiation. Finally, light from the ground can also be reflected by the atmosphere, changing the brightness of the night sky.

40. The idea that we put astronomical telescopes in orbit to get closer to the objects we are observing is incorrect. First off the reason we put telescopes in orbit is not to get closer to the objects but to be able to make observations without the atmosphere in the way. Still, even if that were not the case, putting the telescopes in orbit does not get us significantly closer to the objects we are observing. The scale of the universe is enormous and the distance the telescopes are away from Earth is insignificant to the distance between Earth and the objects that we are observing with those telescopes.