Physics
Kepler's Laws Worksheet **Name**__________________________

Fill in the blank.
1st Law: The planets move about the sun in ____________________________, with the sun at one ______________.

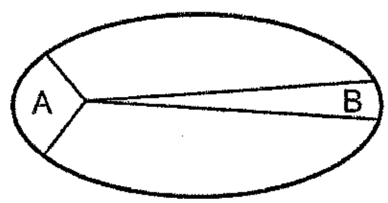
2nd Law: The straight line joining the sun and a given planet sweeps out ________________________ in ________________________________.

3rd Law: State the equation __________________________
Define the variables:
T = ____________________________________
r = ____________________________________

Answer all questions.

1. A planet is in orbit as shown below. Where are the two possible locations for a Sun?

2. In the picture below, the area in section A = the area in section B.



   a. According to Kepler's 2nd law, which section takes more time for the planet to travel?

   b. What does this mean about the relative speed of an orbiting body?

3. Kepler's First Law states that a planet moves on an ellipse around the sun. Where is the sun with respect to that ellipse?

4. Between March 21 and September 21, there are three days more than between September 21 and March 21. These two dates are the spring and fall equinoxes, when the days and nights are of equal length. Between the equinoxes, the Earth moves 180° around its orbit with respect to the sun. Using Kepler's 2nd Law, explain clearly how you can determine the part of the year during which the Earth is closer to the sun.

5. What is the orbital period of earth in years? In days?

Solve the following problems.

6. A spy satellite is located one Earth radius above the surface of the Earth. What is its period of revolution?

$T = 14{,}339.8$ sec

7. Mars has two moons, Phobos and Deimos (Fear and Panic, the companions of Mars, the god of war). Deimos has a period of 30 h 18 min and a mean distance from the center of Mars of 2.3×10^4 km.

a) If the period of Phobos is 7 h 39 min, what mean distance is it from the center of Mars?

$r_p = 9187.7$ km

b) A Martian lander is to be placed in orbit around Mars at a mean altitude of 100 km. What will be the period of the Martian lander?

$T_M = 6393$ sec

8. Communications satellites are placed in orbit so that they remain stationary relative to a specific area on the Earth's surface. They are given the name **synchronous satellites** because, to maintain such a position, their period as they orbit must be the same as the Earth's. What is the height of such a satellite measured from

a) the center of the Earth?

$r_s = 4.2 \times 10^7$ m

b) the surface of the Earth?

3.6×10^7 m

9. You are sitting in the family car with your pesky younger sibling. S/He is getting annoyingly close to your "personal space." Your centers of masses are 0.50 meters apart. If your masses are 50.00 kg and 70.00 kg, then what is the actual scientific force of attraction between the two of you?

9.3×10^{-7} N

10. What is the force of attraction between a 60.0 kg student in the senior parking lot and the school? The distance between the two is 100.000 m and the mass of the school 65,000,000 kg.

2.6×10^{-5} N

11. Two asteroids, (m1 = 1.00×10^{12} kg and m2 = 5×10^{12} kg), are floating in space. The force of attraction between them is 10.000 N. How far apart are their centers of mass?

5.8×10^6 m

12. While on the surface of the Earth a student has a weight of 450 N. If she is moved twice as far from the center of the Earth, then how does her new weight compare to her old?

112.5 N

or

$\frac{1}{4}$ of original weight

Lyzinski, CRHS-South

Accelerated Physics
"Kepler's Laws" Worksheet

1. Using the table below, find the Kepler Constant for each of the objects below (including the moon, but excluding the sun). Explain why the answers make sense.

Object	Mass (kg)	Radius of object (m)	Period of rotation on axis (s)	Mean radius of orbit (m)	Period of revolution of orbit (s)	Kepler constant R^3/T^2 (m^3/s^2)
Sun	1.98×10^{30}	6.95×10^{8}	2.14×10^{6}	---	---	---
Mercury	3.28×10^{23}	2.57×10^{6}	5.05×10^{6}	5.79×10^{10}	7.60×10^{6}	
Venus	4.83×10^{24}	6.31×10^{6}	2.1×10^{7}	1.08×10^{11}	1.94×10^{7}	
Earth	5.98×10^{24}	6.38×10^{6}	8.61×10^{4}	1.49×10^{11}	3.16×10^{7}	
Mars	6.37×10^{23}	3.43×10^{6}	8.85×10^{4}	2.28×10^{11}	5.94×10^{7}	
Jupiter	1.90×10^{27}	7.18×10^{7}	3.54×10^{4}	7.78×10^{11}	3.74×10^{8}	
Saturn	5.67×10^{26}	6.03×10^{7}	3.60×10^{4}	1.43×10^{12}	9.30×10^{8}	
Uranus	8.80×10^{25}	2.67×10^{7}	3.88×10^{4}	2.87×10^{12}	2.66×10^{9}	
Neptune	1.03×10^{26}	2.48×10^{7}	5.69×10^{6}	4.50×10^{12}	5.20×10^{9}	
Pluto	6×10^{23}	3×10^{6}	5.51×10^{5}	5.9×10^{12}	7.82×10^{9}	
moon	7.34×10^{22}	1.74×10^{6}	2.36×10^{6}	3.8×10^{8}	2.36×10^{6}	

2. A planet's mean distance from the sun is 2.0×10^{11} m. What is its orbital period?

3. If a small planet were discovered whose orbital period was twice that of the Earth, how many times farther from the sun would this planet be?

4. Using the data from the table below, determine the Kepler constant for any satellite of the Earth. (Note: The moon is a satellite of the Earth.)

Natural Satellites in the Solar System*

Planet	Mass (m_E=1)	Satellite	Orbital Radius (x 10^6 m)	Period (d)
Earth	1.00	Moon	384.4	27.322
Mars	0.107	Phobos	9.38	0.319
		Deimos	23.46	1.262
Jupiter	318	Thebe	221.9	0.675
		Io	421.6	1.769
		Europa	670.9	3.551
		Elara	11,737	259.7
Saturn	95.2	Janis	151.47	0.695
		Mimas	185.54	0.942
		Calypso	294.67	1.888
Uranus	14.6	Miranda	129.4	1.414
		Ariel	191.0	2.520
		Oberon	583.5	13.463
Neptune	16.72	Triton	355.3	5.877
		Nereid	5,510	360.21
Pluto	0.002	Charon	19.7	6.387

*"Planetary Satellites: An Update", *Sky and Telescope*, November 1983.