Chapter 7
Gravitation

7-1

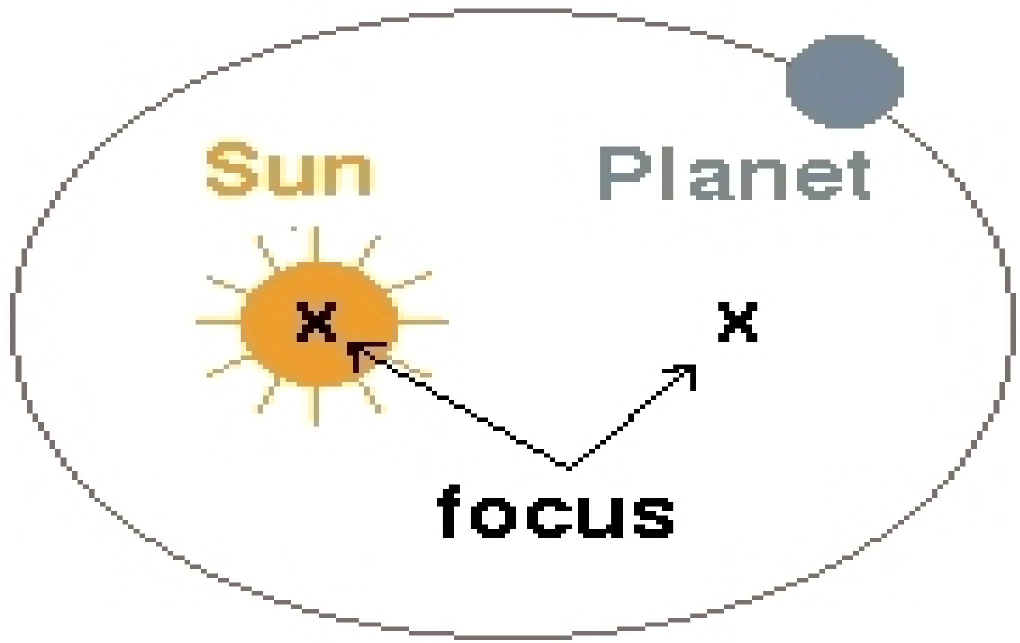
Planetary Motion and Gravitation

Johannes Kepler

- Believed that the __________ exerted a __________ on all of the planets and that the sun was the __________________ of the system.
- Discovered three laws that ___________ the motion of every _______________ and every ________________.

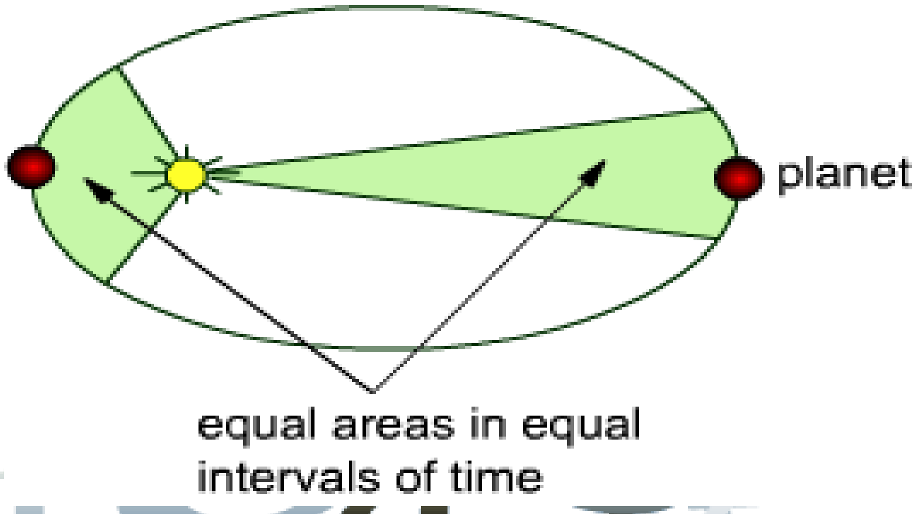
Kepler's 1st Law

- Planets ___________________________ in ______________________ with the Sun at ____________________



Kepler's 2nd Law

- An imaginary line from the __________to a ____________ sweeps out __________________ in _____________________ intervals.
- Meaning – planets move ______________ when they are _______________to the Sun and _______________ when they are ________________ from the Sun.

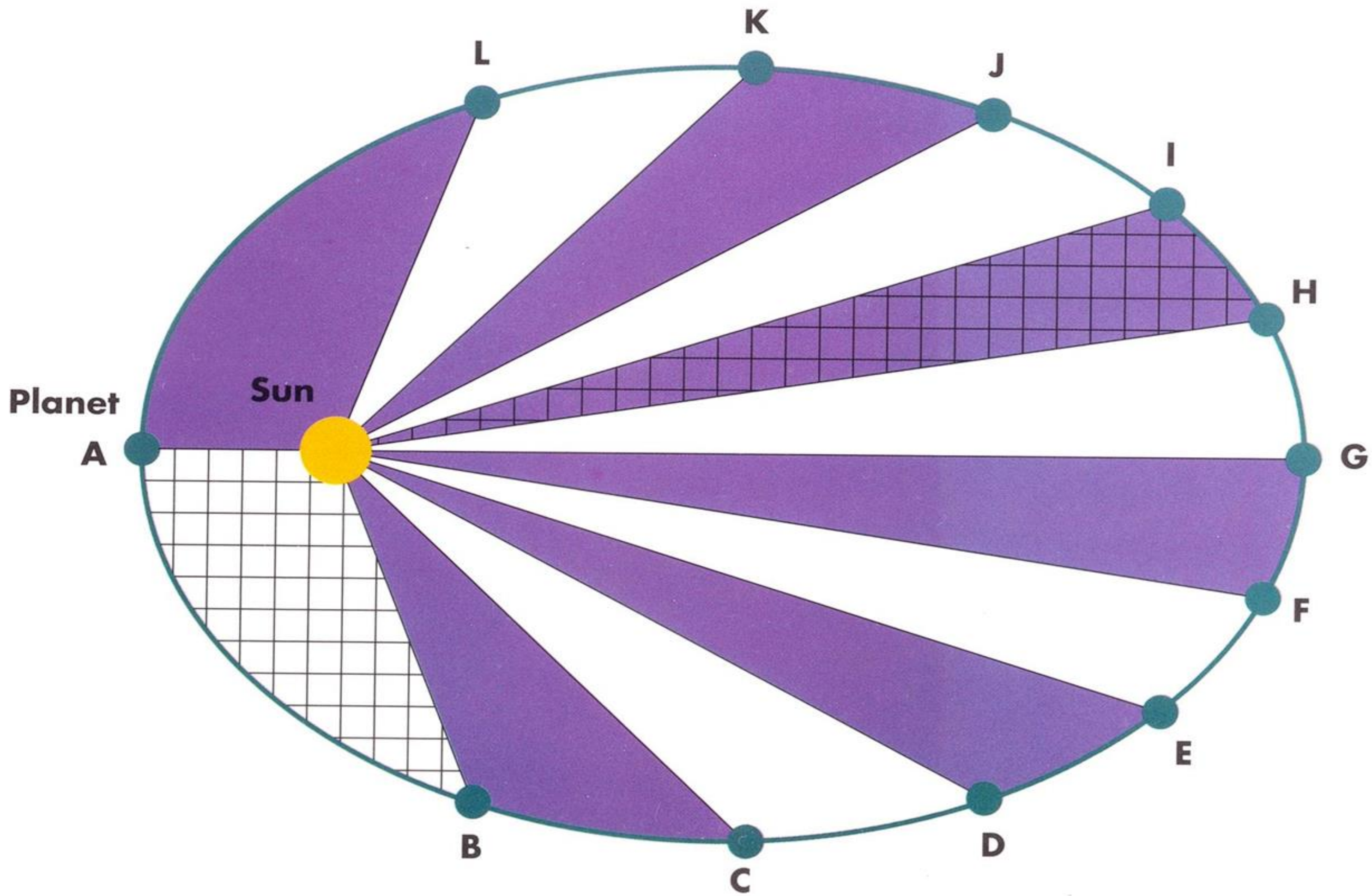


Keplers Second Law

The line from planet to Sun sweeps out equal area in equal time.

For example, if the time taken for the planet to get from A to B is equal to the time for the planet to get from H to I, then the crosshatched areas are equal.

This law is just a consequence of the law of the conservation of angular momemtum.



TA 29
Kepler's second law (Fig. 4-15)

For use with Fix: *Astronomy: Journey to the Cosmic Frontier*

Kepler's 3rd Law

- The squared quantity of the period of object A divided by the period of object B is equal to the cubed quantity of object A's average distance from the Sun divided by object B's average distance from the Sun.

Kepler's 3rd Law

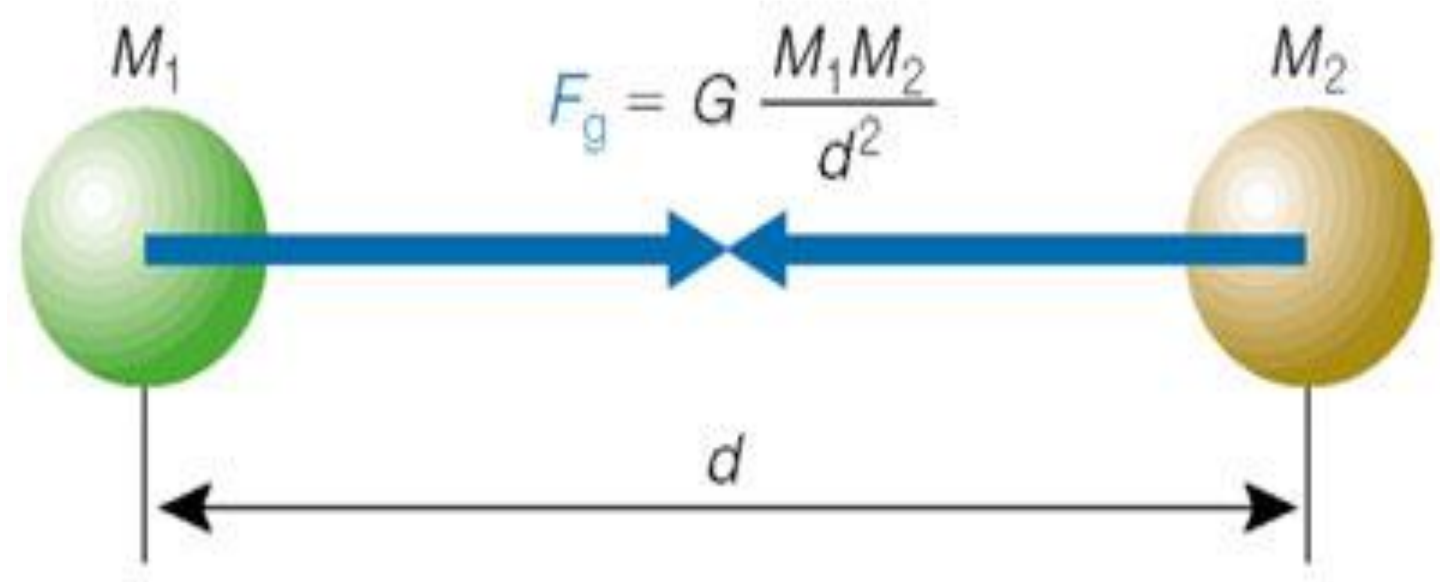
- The third law relates the motion of ____________ ______________ about a _______________________.
- EX:
- EX:

- EX: Galileo measured the orbital sizes of Jupiter's moons using the diameter of Jupiter as a unit of measure. He found that Io, the closest moon to Jupiter, had a period of 1.8 days and was 4.2 units from the center of Jupiter. Callisto, the fourth moon from Jupiter, had a period of 16.7 days. Using the same units that Galileo used, predict Callisto's distance from Jupiter.
- EX: Europa, a satellite of Jupiter, has a period of 3.55 days. How many units is its radial distance?

Newton and Planetary Motion

- Gravitational Force – the ________________ __________________________between two objects.
- The force acts in the __________________of the line _______________________________ of the two objects.
- The force is ______________________________to the ____________________________ between the centers of the planet and the Sun:
- The force is ____________________ to the _________ of the two objects:

Law of Universal Gravitation



Credit: Pearson Education, Inc.

Period of a Planet Orbiting the Sun

Universal Gravitational Constant

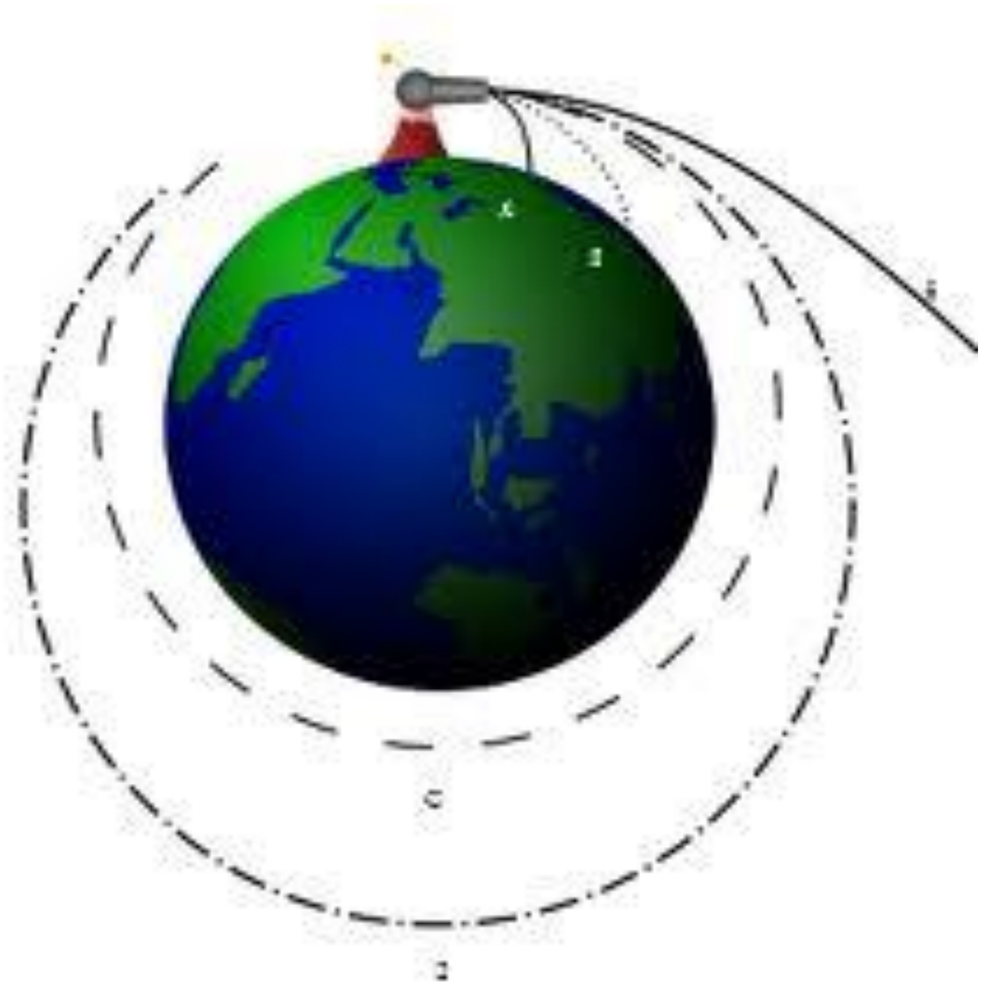
- G =
- Henry Cavendish calculated this constant in 1798 by finding the gravitational force between two lead spheres, with a known mass and a measured distance between there centers
- Once G was known, the Earth's mass could be calculated, the Sun's mass could be calculated, and the gravitational force between any two objects can be calculated.

7-2

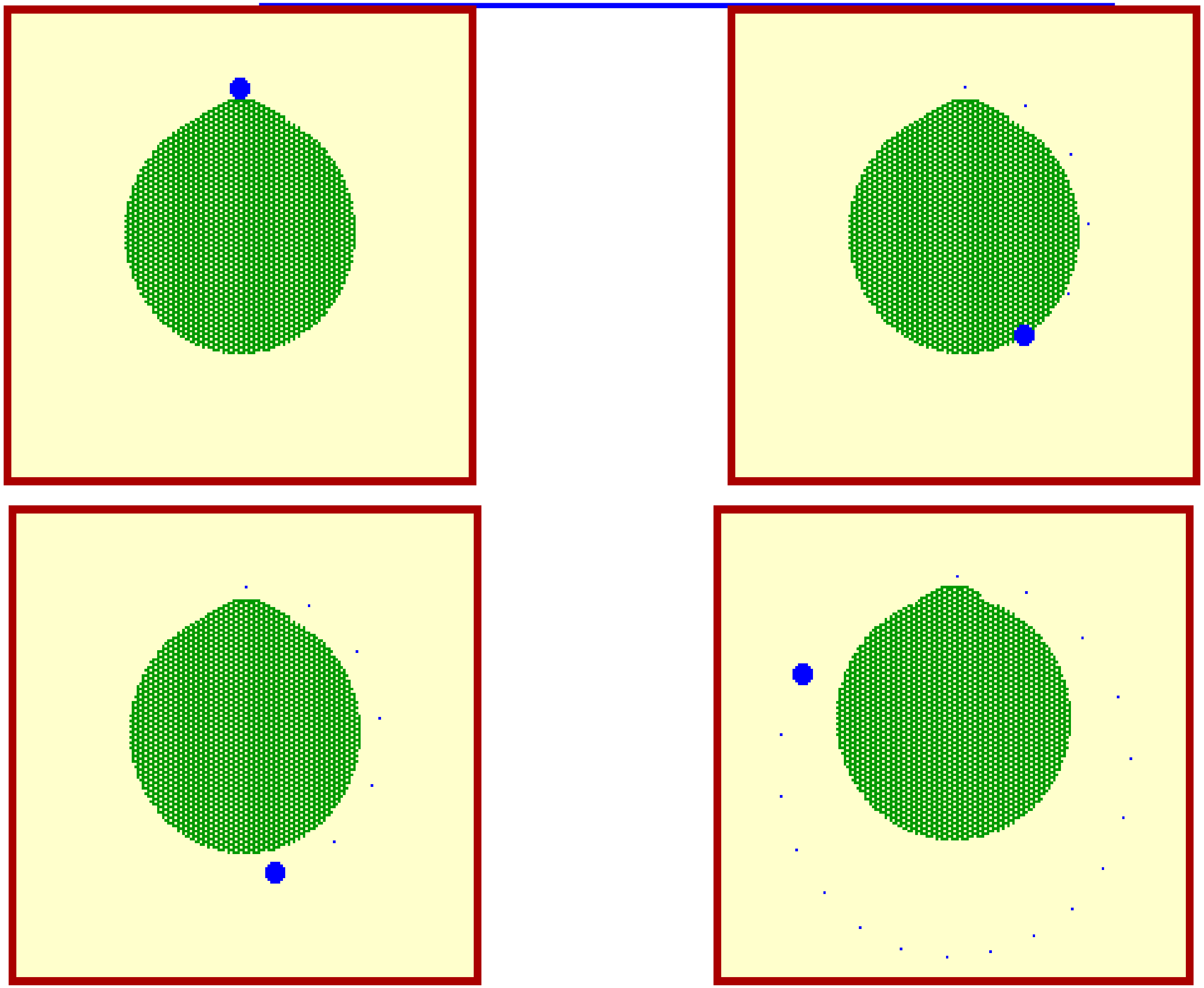
Using the Laws of Universal Gravitation

How Objects Get Into Orbit

- An object shot horizontally is a projectile – it will fall to the Earth in a parabolic path.
- The faster a projectile is shot horizontally, the father it will get horizontally.
- If a projectile is shot ___________________ and ____, it will ________________________ at the same rate that the ___________________________________.
  - Meaning the object would ______________________



- http://www.physicsclassroom.com/mmedia/vectors/sat.cfm



Speed of a Satellite Orbiting the Earth

Period of a Satellite Orbiting the Earth

Launching a Satellite

- Satellites are launched by ________________ that have __________________ them to a ___________ _________________________ that will allow them to _________________________.
- Since F = ma, a more _________________ satellite would require more ____________ to accelerate it.
- Therefore, the mass of a satellite is limited by the rocket that will be used to launch it.
- http://www.youtube.com/watch?v=mbeoS0o_fNw

Uses of a Satellite

- Provides images of Earth's surface that are used to:
- Create maps
- Study land use
- Monitor resources
- Monitor global changes

EX:

- Engineers are planning to place the International Space Station (ISS) into orbit at an altitude of 450 km above the Earth's surface. What would be the orbital speed and period of the ISS?

Acceleration Due to Gravity

- As you move ______________________________ (as r becomes larger), the __________________ ______________________ is ________________.

- EX: 400 km above the Earth's surface, the acceleration due to gravity is 8.7 m/s^2.

- How then, can this astronaut, who is in orbit 400 km above the Earth, feel “weightless”?

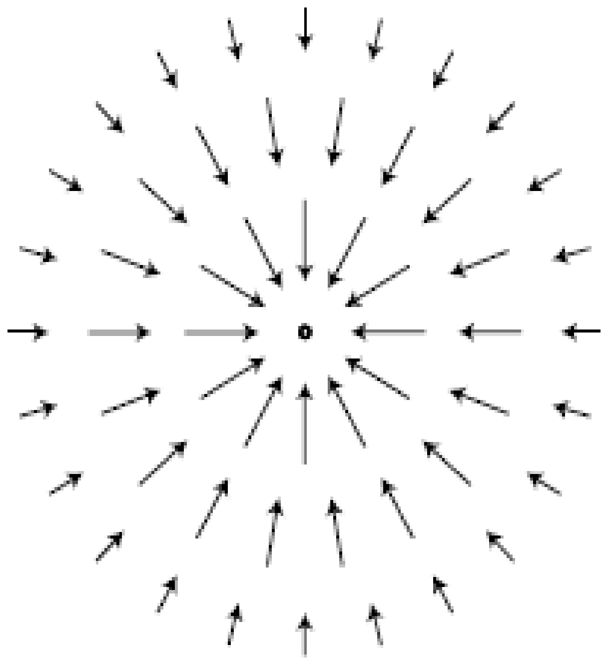
Weightlessness

- Remember – you only ______________________ when something is exerting a ________________ ________________ on you
- EX:
- If your chair or the floor were to be ____________ OR if they were to ________________ towards Earth at the same rate as you, you would feel ____ ____.

- Since a space shuttle and everything in it ___________________________________ – the astronaut can experience ________________
- Astronauts In Orbit

Gravitational Field

- Gravity is a _________ _____________force
  - No _____________ needed
- Any object with a ____________ is surrounded by a gravitational field, that always points _________________________ ______________________.



Gravitational Field

- Gravitational field is a _______________ in which ____________________________ can be experienced.
- Any mass within the gravitational field experiences a __________ caused by the interaction of its mass with ___________________ ____________ at that _________________________.
- http://physics.bu.edu/~duffy/semester1/c17_field.html

Gravitational Field

- Gravitational field strength (g) is equal to the ______________________ experienced per ________ ____________ in a gravitational field.

- Units: N/kg which also equals m/s^2
- Note: This expression is the __________ as that of an _________________ of a mass due to a ________.
- EX: Earth's gravitational field strength is ______, which is equal to the ___________________________ on Earth.

Gravitational Field

- To calculate gravitational field given only the mass of the center body (M) and the distance another mass is away (r):

- Note: The gravitational field depends on the __________of the ______________________, not the ________ of the ______________________________.
- Gravitational field is a ____________.