


Gravity

Pisa Principle Revisited




☛ You get into an elevator at the top of the Sears Tower. A terrorist cuts the cable. As the elevator begins to fall, you find that you are...

1. thrown to the floor.
2. floating around in the cab.
3. rise to the ceiling.

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Gravity

"Weightlessness"



Everything floats in a spaceship if...

- 1) Coasting through space, or
- 2) In free fall, or
- 3) In orbit

Even though you have no weight, you still have mass ...


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Gravity

Mass vs. Weight

- ☛ **weight** is the force of gravity
 - ✧ It varies from planet to planet
- ☛ **Mass** is the amount of matter
 - ✧ It is the same on all planets.

Planet	Mass	Weight
Earth	100 kg	220 lb
Moon	100 kg	35 lb
Jupiter	100 kg	550 lb



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Gravity

The Law of Gravity

gravitational constant

masses

force

$$F = \frac{G m_1 m_2}{r^2}$$

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Gravity

Comments

- 1) Everything has gravity.
- 2) The Law of Gravity is the same everywhere.
- 3) Kepler's Laws derived mathematically.
- 4) Convinced everyone the Sun was in the center.

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Gravity

Surface Gravity

- ☞ g = acceleration of gravity
- ☞ g different on other planets
- ☞ In general, g is greater on larger planets.

Earth	Moon	Jupiter
10 m/s/s	1.6 m/s/s	25 m/s/s
100 lb	16 lb	250 lb

mass of planet

distance from center of planet


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Weight

- weight is the force of gravity
- Newton's 2nd Law
force = (mass)(acceleration)
- Unit of force = Newton (N)
- weight = (mass)(g)

	Earth	Moon
g	10 m/s/s	1.7 m/s/s
mass	100 kg	100 kg
weight	1000 N	170 N



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Gravity

Practice Question

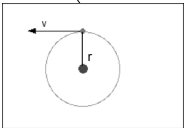
- Venus has a surface gravity of 8.9 m/s/s. Mars has a surface gravity of 3.7 m/s/s.

- On which planet will you weigh more?
- On which planet will your mass be greater?

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Gravity

Circular Speed



- Criteria for circular orbit:
 - Direction is horizontal (tangential)
 - Speed is a critical value: v_{circ}

bigger $r \rightarrow$ lower v


$$v_{\text{circ}} = \sqrt{\frac{\text{Mass of planet}}{\text{Distance to center of planet}}}$$

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Gravity

Geosynchronous Orbit

- ☛ Low Earth Orbit
 - ☒ Altitude = 300 km
 - ☒ $V = 8 \text{ km/s}$
 - ☒ Period = 90 minutes
- ☛ Geosynchronous Orbit
 - ☒ altitude = 42,000 km
 - ☒ $V = 3 \text{ km/s}$
 - ☒ Period = 23 h 56 m



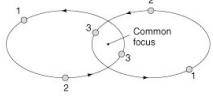
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Gravity

Orbital Motion Revisited

- ☛ Newton's 3rd Law

The force of star A on star B is equal and opposite to the force of star B on star A.
- ☛ binary star system: 2 stars orbit about a common center.



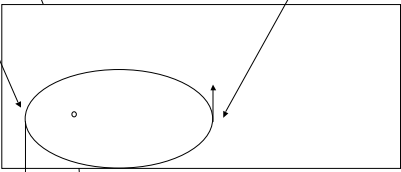
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Elliptical Orbits

Kepler's First Law Revisited

perihelion: $v > v_{\text{circ}}$ aphelion: $v < v_{\text{circ}}$



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Escape Speed

- Speed of object falling from far away.
- Speed just fast enough to escape
- $= \sqrt{2} (v_{\text{circ}}) = 1.4 (v_{\text{circ}})$
- Earth: $v_{\text{esc}} = 11 \text{ km/s}$

v_{esc}

parabola

$v > v_{\text{esc}} \rightarrow$
hyperbola

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Escape

Q. To escape the Earth's gravity, a rocket must...

- Go straight up.
- Go up at least 100 miles.
- Go at least 11 km/s.

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Conic Sections


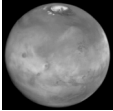
<u>Bound orbits</u>		<u>Unbound orbits</u>	
circle $e = 0$			parabola $e = 1$
ellipse $0 < e < 1$			hyperbola $e > 1$

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Gravity

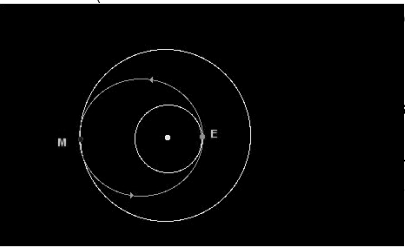
Travel to Other Planets

- Use rockets only to change speed
- Coast most of the way.
- Spaceship obeys Kepler's Laws.
- A little planet.

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Trip to Mars

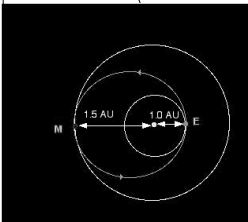


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ars to
atch

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Gravity

Trip to Mars




s.a.m. = 1.25 AU
 $(\text{period})^2 = (\text{s.a.m.})^3$
 period = 1.4 years
 to Mars = 0.7 years = 8 months

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 Gravity

Our New Home



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