Wrocław University of Science and Technology

Physics

JZL1001913C

summer semester

2020/2021

Wednesday, 18:20 - 19:50

Friday, 18:20 - 19:50

virtual room (ZOOM)

Sylwia Majchrowska

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https://majsylw.netlify.app/

room 213, building L-1

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Outline

- Introduction - Physics rules the world
- Motion phenomena - Kinematics
- Motion phenomena - Dynamics
- Rotational motion
- **Harmonic motion**
- **Gravitational field**
- Relativistic phenomena
- Basics of Thermodynamics
- Principles of Thermodynamics
- Kinetic theory of matter
- Electrostatics
- Electric current
- Magnetic field
- Vibrations and electromagnetic waves
- Optics
- Quantum nature of radiation
- Nuclear Physics

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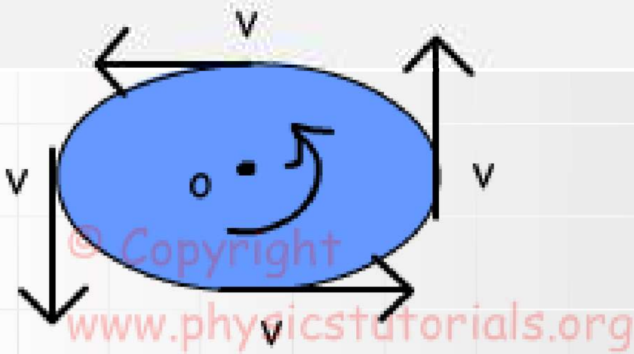
Rotational motion - rewiev

Force [1 Newton=1kg * m/s^2]
Centripetal force F_c=-m4π²r/T²
Centrifugal force $$F_c = ma_c = \frac{mv^2}{r}$$ $$a_c = \frac{v}{t}\hat{r} = \frac{r\omega}{t}\hat{r} = v\omega = \frac{v^2}{r}$$



Quantities:
- Angular displacement
- Period and frequency
- Angular velocity
- Angular acceleration
- Centripetal and centrifugal force

Angular displacement $\Delta\theta = \theta_2 - \theta_1$	Unit rad
Angular velocity $\omega = 2\pi/T$	Unit rad/s
Angular acceleraton $\alpha = (\omega_{final} - \omega_{initial})/t$	Unit rad/s^2
Period -> T [s] Frequency -> 1/T	Unit 1 Herz = 1 1/s

Rotational motion - kinematics

Translational Motion		Rotational Motion
$v = v_0 + at$	$\longrightarrow$	$\omega = \omega_0 + \alpha t$
$x = x_0 + v_0 t + \frac{1}{2}at^2$	$\longrightarrow$	$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$
$v^2 = v_0^2 + 2ax$	$\longrightarrow$	$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$

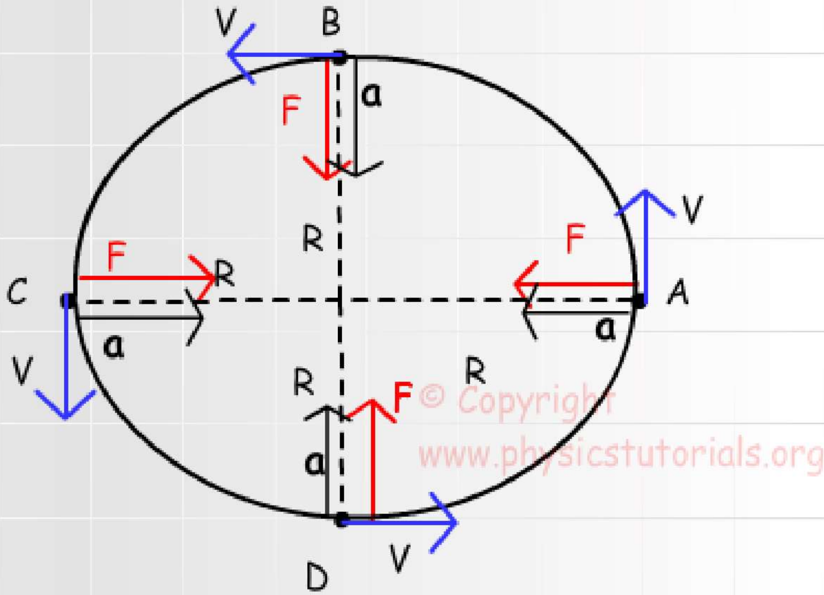
Where

- θ_0 = initial angular displacement of the rotating body
- ω_0 = initial angular velocity of the body.
- $\propto$ = angular acceleration, which is constant is this section.

Rotational motion - dynamics

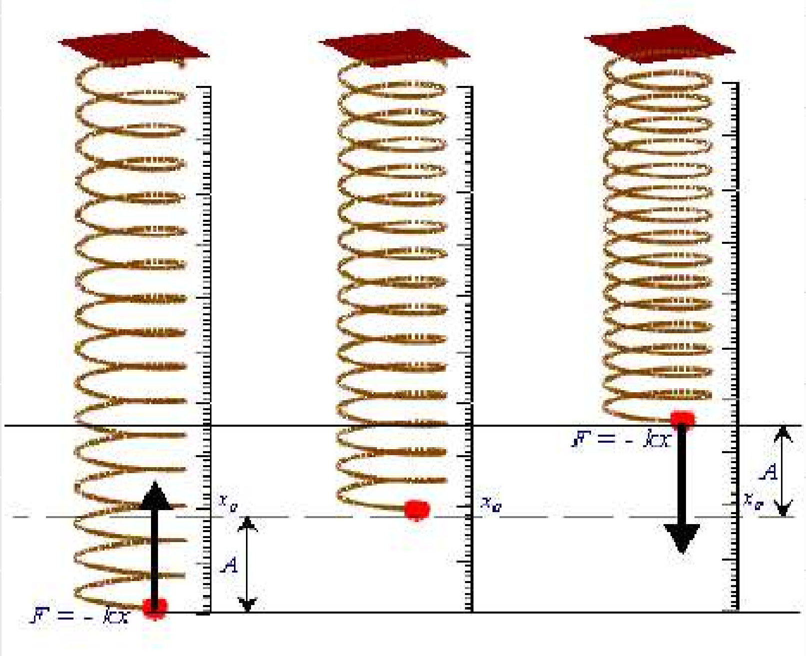
We can write the torque equation like:

T=Applied Force x Distance



Harmonic motion

Simple harmonic motion is governed by a restorative force. For a spring-mass system, such as a block attached to a spring, the spring force is responsible for the oscillation.



$$F = ma$$

$$-kx = ma$$

$$a = -\frac{k}{m}x$$

Since the restoring force is proportional to displacement from equilibrium, both the magnitude of the restoring force and the acceleration is the greatest at the maximum points of displacement. The negative sign tells us that the force and acceleration are in the opposite direction from displacement.

Please see course: https://www.khanacademy.org/science/ap-physics-1/simple-harmonic-motion-ap

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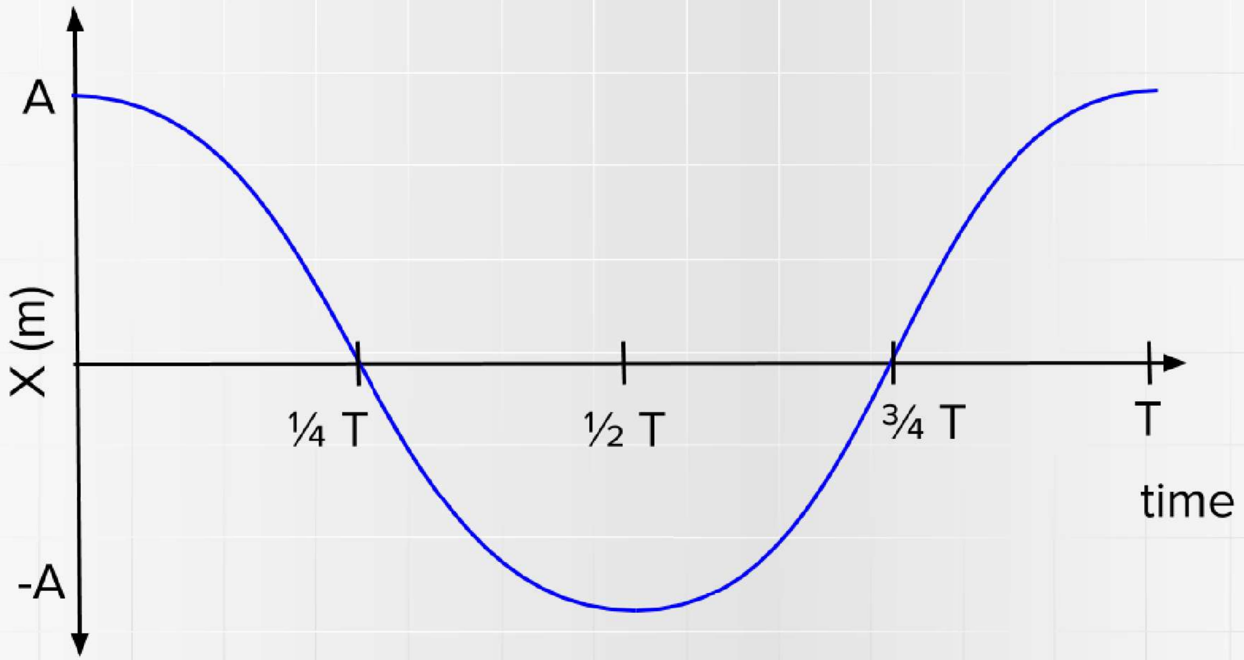
Period and frequency

We can graph the movement of an oscillating object as a function of time. Frequency *f* and period *T* are independent of amplitude *A*. We can find the period *T* by taking any two analogous points on the graph and calculating the time between them. It's often easiest to measure the time between consecutive maximum or minimum points of displacement. Once the period is known, the frequency can be found using $f=1/T$.



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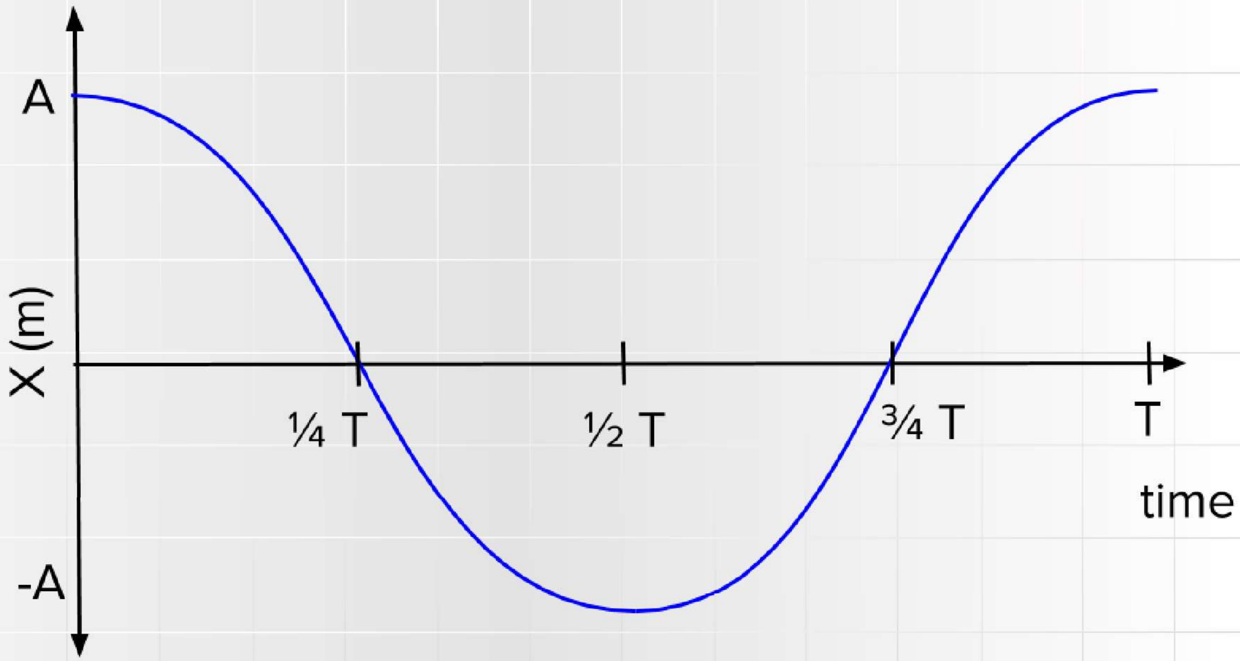
Simple Harmonic Motion

Displacement as a function of time is proportional to amplitude and the cosine of *2πft*. *x* is displacement as a function of time, where A is amplitude, *f* is frequency, and *t* is time

$$x(t) = A\sin(2\pi f t)$$



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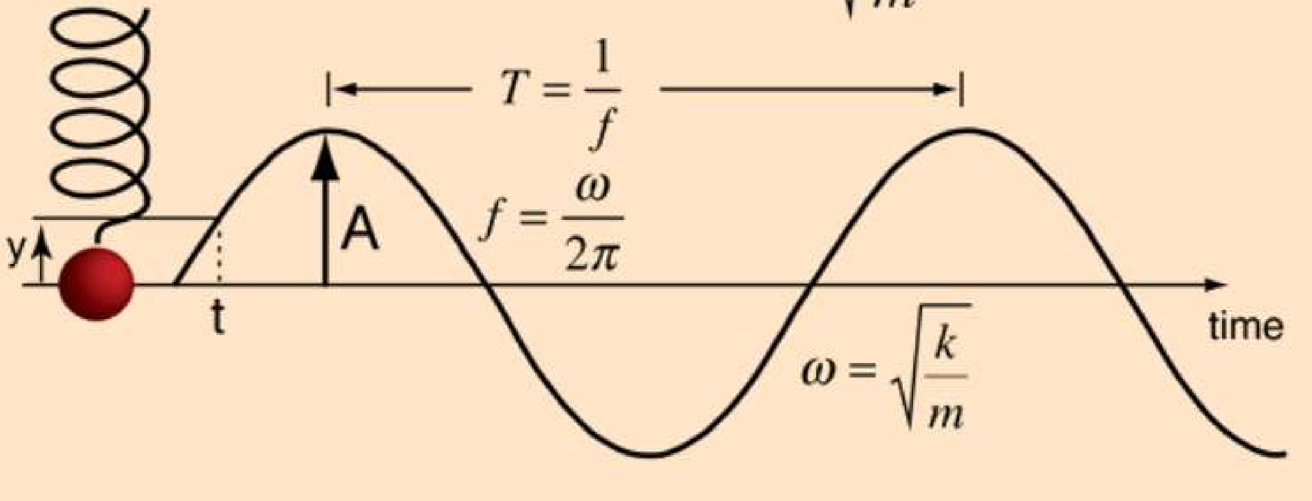
Simple Harmonic Motion

Calculation

The motion equations for simple harmonic motion provide for calculating any parameter of the motion if the others are known.

$$y = A\sin\omega t = A\sin\sqrt{\frac{k}{m}}\,t$$



If the period is T = 5 s

then the frequency is f = Hz and the angular frequency = rad/s.

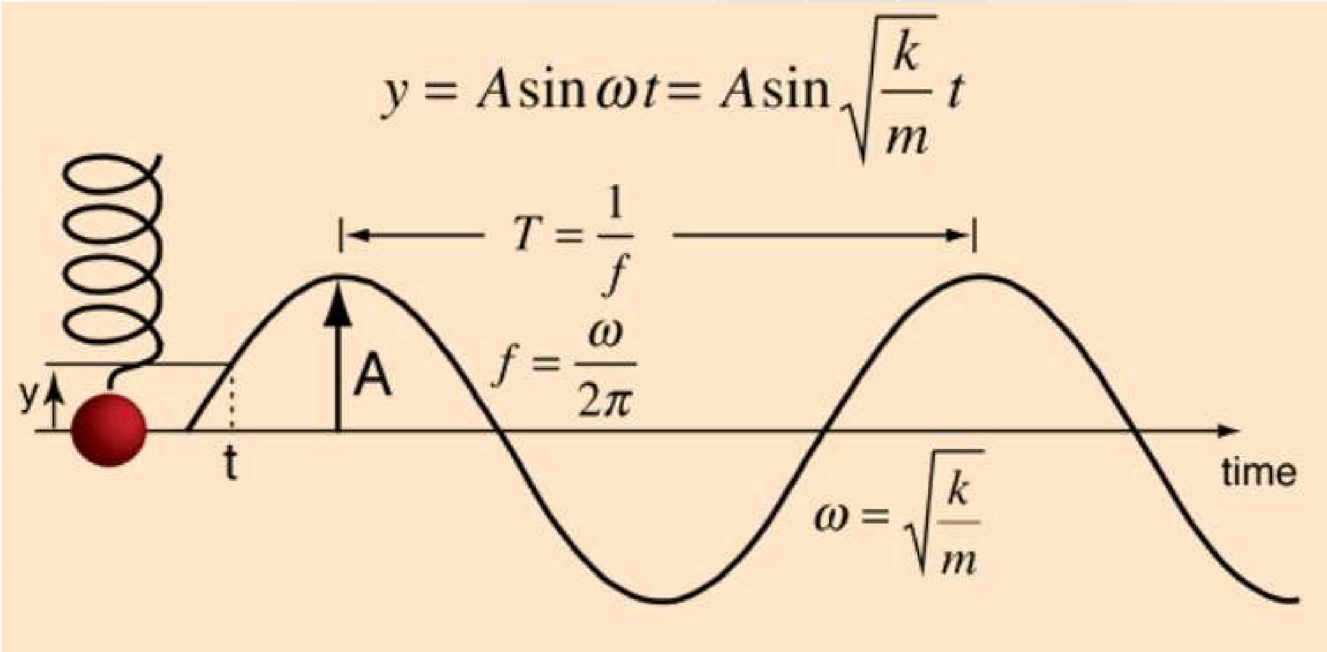
The motion is described by

Displacement = Amplitude x sin (angular frequency x time)

Simple Harmonic Motion

Calculation

The motion equations for simple harmonic motion provide for calculating any parameter of the motion if the others are known.



If the period is T = 5 s

then the frequency is f = 1/T=1/5s=0.2 Hz and the angular frequency = 2pi*f= 2*3.14*0.2 = 1.256 rad/s.

The motion is described by

Displacement = Amplitude x sin (angular frequency x time)

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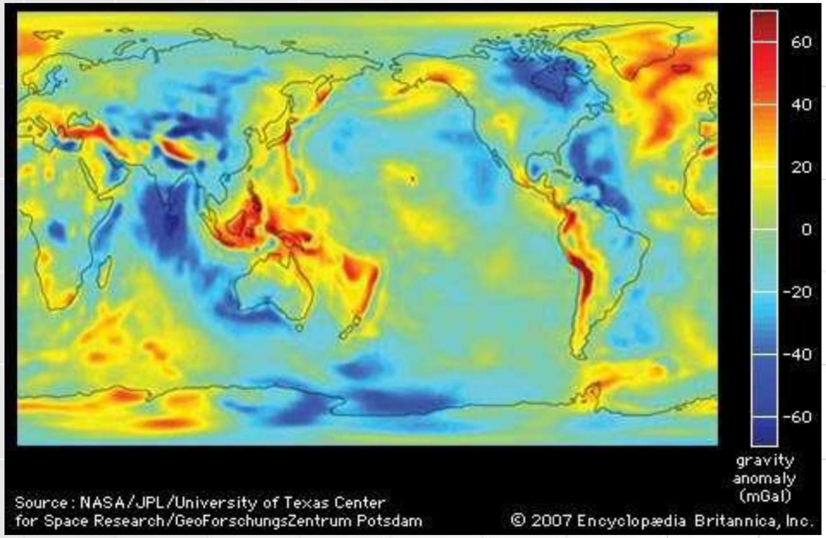
Gravity is More Than a Name

Nearly every child knows of the word **gravity**. Gravity is the name associated with the mishaps of the milk spilled from the breakfast table to the kitchen floor and the youngster who topples to the pavement as the grand finale of the first bicycle ride. Gravity is the name associated with the reason for "what goes up, must come down," whether it be the baseball hit in the neighborhood sandlot game or the child happily jumping on the backyard mini-trampoline. We all know of the word gravity - it is the *thing* that causes objects to fall to Earth. Yet the role of physics is to do more than to associate words with phenomenon. The role of physics is to explain phenomenon in terms of underlying principles. The goal is to explain phenomenon in terms of principles that are so universal that they are capable of explaining more than a single phenomenon but a wealth of phenomenon in a consistent manner. Thus, a student's conception of gravity must grow in sophistication to the point that it becomes more than a mere name associated with falling phenomenon. Gravity must be understood in terms of its cause, its source, and its far-reaching implications on the structure and the motion of the objects in the universe.

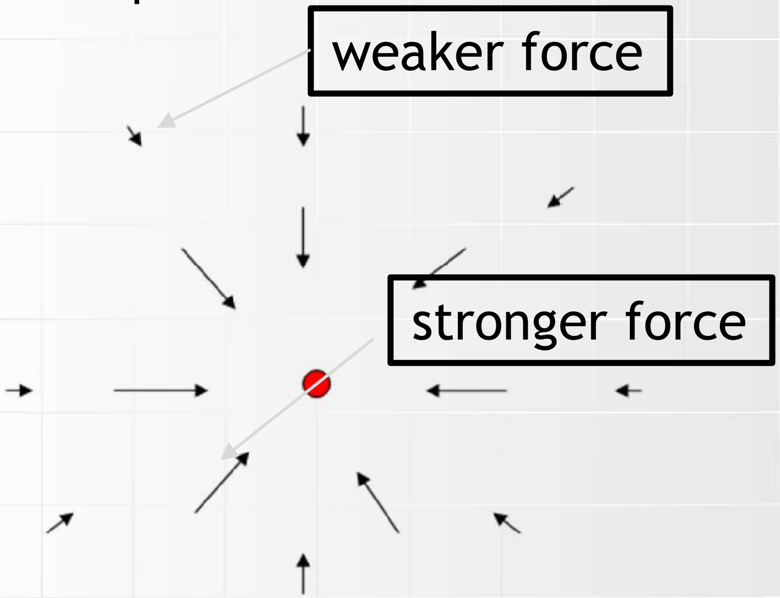
Please see course:

https://www.khanacademy.org/science/ap-physics-1/ap-centripetal-force-and-gravitation/newtons-law-of-gravitation-ap/v/introduction-to-gravity

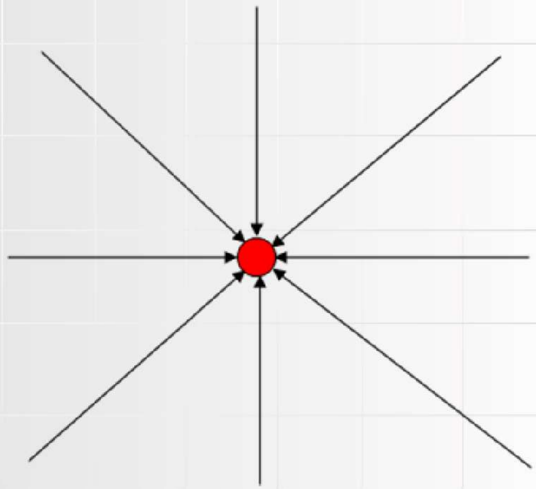


Field from a Single Point Mass

We know this field has strength **GM/r^2**, and points towards the mass — the direction of the attraction. Let's draw it anyway, or, at least, let's draw in a few vectors showing its strength at various points. We can represent a field by drawing "field lines", curves such that at every point along the curve's length, its direction is the direction of the field at that point.



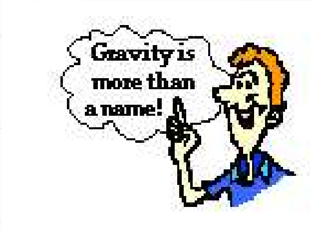
indicate direction and strength of the field



indicate only directon of the field

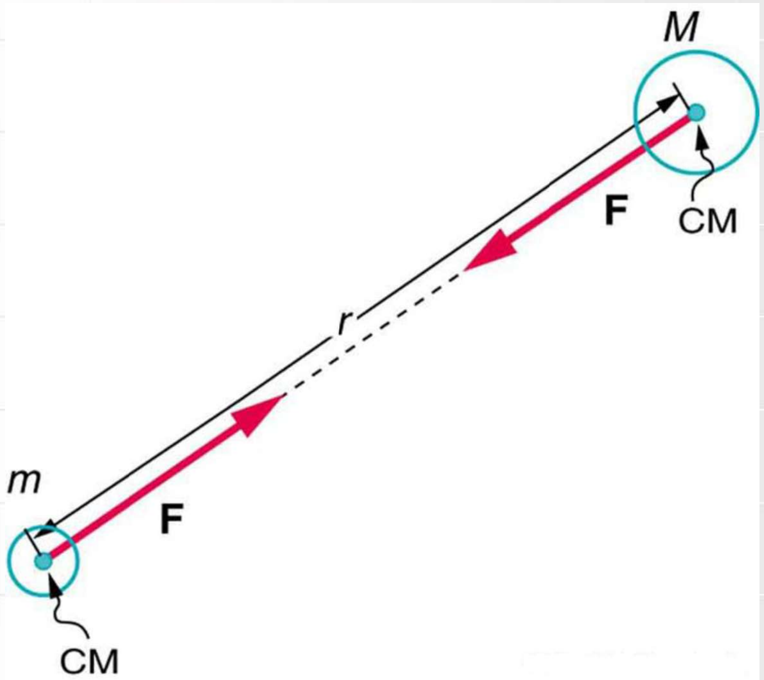
Force of gravity in case of Earth

Certainly gravity is a force that exists between the Earth and the objects that are near it. As you stand upon the Earth, you experience this force. We have become accustomed to calling it the **force of gravity** and have even represented it by the symbol $\mathbf{F_{grav}}$



Not to be confused with the force of gravity ($\mathbf{F_{grav}}$), the acceleration of gravity (**g**) is the acceleration experienced by an object when the only force acting upon it is the force of gravity. On and near Earth's surface, the value for the acceleration of gravity is approximately 9.8 m/s/s. It is the same acceleration value for all objects, regardless of their mass (and assuming that the only significant force is gravity)

Interaction between bodies



Gravitational attraction is along a line joining the centers of mass of these two bodies. The magnitude of the force is the same on each, consistent with Newton's third law.

The gravitational force is relatively simple. It is always attractive, and it depends only on the masses involved and the distance between them. Stated in modern language, **Newton's universal law of gravitation** states that every particle in the universe attracts every other particle with a force along a line joining them. The force is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Newton’s universal law of gravitation

The bodies we are dealing with tend to be large. To simplify the situation we assume that the body acts as if its entire mass is concentrated at one specific point called the center of mass. For two bodies having masses m and M with a distance r between their centers of mass, the equation for Newton’s universal law of gravitation is

$$F = G\frac{mM}{r^2}$$

where F is the magnitude of the gravitational force and G is a proportionality factor called the gravitational constant. G is a universal gravitational constant—that is, it is thought to be the same everywhere in the universe. It has been measured experimentally to be

$$G = 6.674 \times 10^{-11} \frac{\mathrm{N \cdot m^2}}{\mathrm{kg^2}}$$

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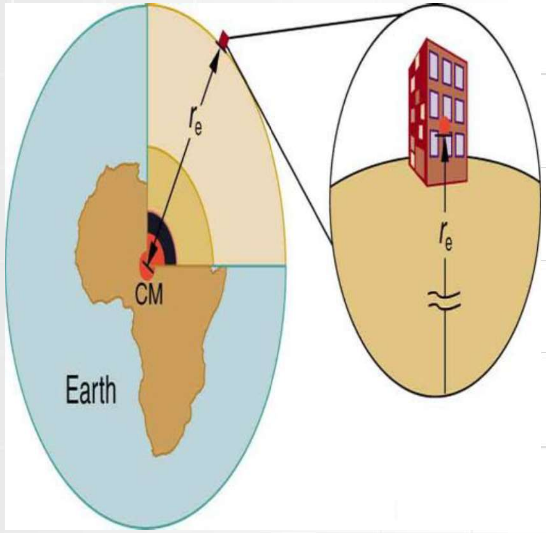
Simpfied calculation of g

Recall that the acceleration due to gravity **g** is about 9.80 m/s^2 on Earth. We can now determine why this is so. The weight of an object mg is the gravitational force between it and Earth. Substituting mg for **F** in Newton's universal law of gravitation gives

$$mg = G\frac{mM}{r^2}$$

where **m** is the mass of the object, **M** is the mass of Earth, and **r** is the distance to the center of Earth (the distance between the centers of mass of the object and Earth). The mass m of the object cancels, leaving an equation for g:

$$g = G\frac{M}{r^2}$$



Substituting known values for Earth's mass and radius (to three significant figures) we can obtain:

$$g = \left(6.67 \times 10^{-11}\frac{\mathrm{N\cdot m^2}}{\mathrm{kg^2}}\right) \times \frac{5.98 \times 10^{24}\ \mathrm{kg}}{(6.38 \times 10^{6}\ \mathrm{m})^2} \longrightarrow g = 9.80\ \mathrm{m/s^2}.$$

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Value of g

The value of the attraction of gravity or of the potential is determined by the distribution of matter within Earth or some other celestial body. In turn, as seen above, the distribution of matter determines the shape of the surface on which the potential is constant. Measurements of gravity and the potential are thus essential both to geodesy, which is the study of the shape of Earth, and to geophysics, the study of its internal structure. For geodesy and global geophysics, it is best to measure the potential from the orbits of artificial satellites. Surface measurements of gravity are best for local geophysics, which deals with the structure of mountains and oceans and the search for minerals.

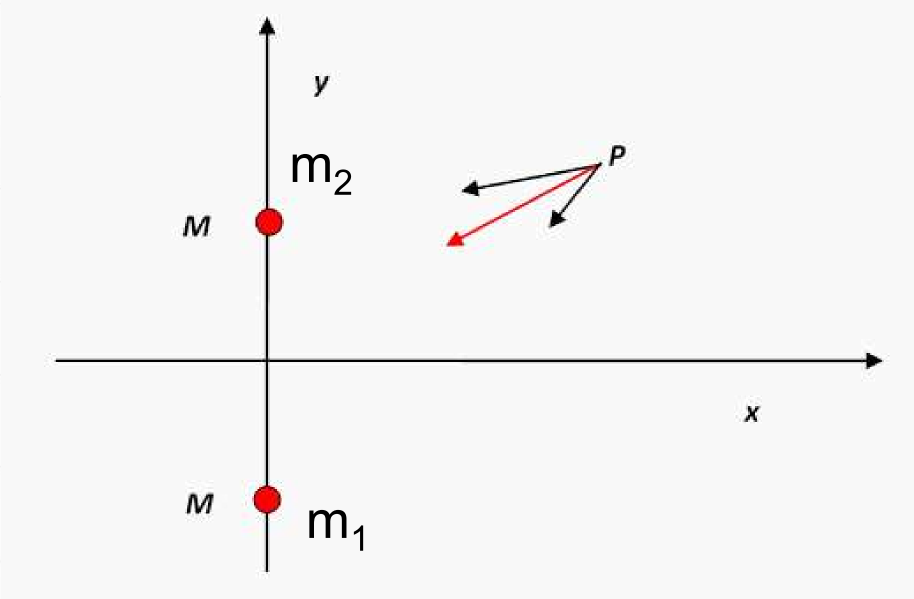
Changes due to location

The acceleration *g* varies by about $^1/_2$ of 1 percent with position on Earth's surface, from about 9.78 metres per second per second at the Equator to approximately 9.83 metres per second per second at the poles.

Changes with time

The gravitational potential at the surface of Earth is due mainly to the mass and rotation of Earth, but there are also small contributions from the distant Sun and Moon. As Earth rotates, those small contributions at any one place vary with time, and so the local value of *g* varies slightly.

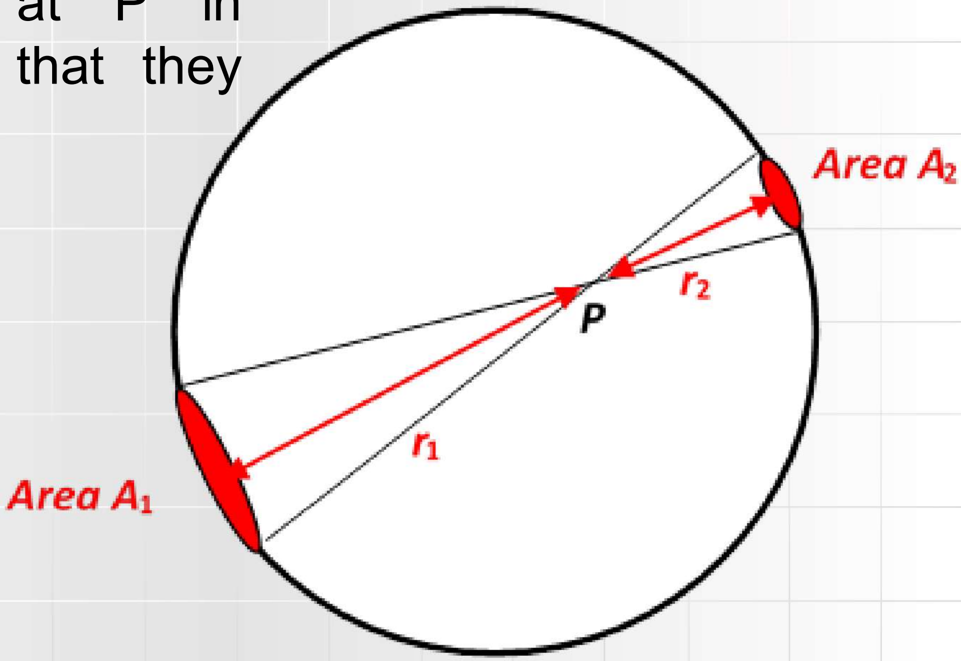
Gravitational Field for Two Masses



Recall Newton's Universal Law of Gravitation states that any two masses have a mutual gravitational attraction $\mathbf{Gm_1m_2/r^2}$. A point mass **m=1** at P will therefore feel gravitational attraction towards both masses M, and a total gravitational field equal to the vector sum of these two forces, illustrated by the red arrow in the figure.

Field Inside a Spherical Shell

We imagine the shell to be very thin, with a mass density ρ kg per square meter of surface. Begin by drawing a two-way cone radiating out from the point P, so that it includes two small areas of the shell on opposite sides: these two areas will exert gravitational attraction on a mass at P in opposite directions. It turns out that they exactly cancel.



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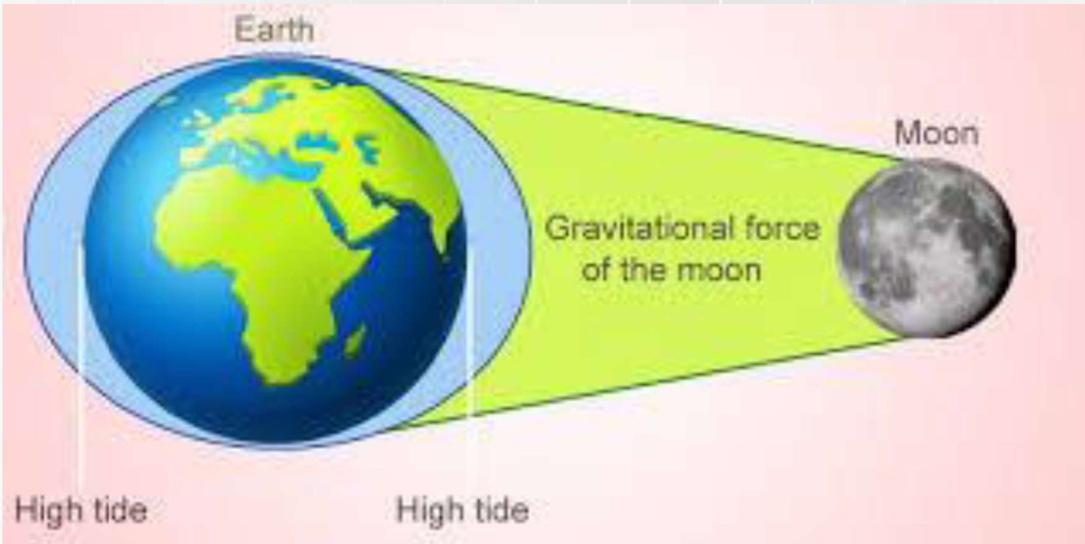
”Weightlessness”

In contrast to the tremendous gravitational force near black holes is the apparent gravitational field experienced by astronauts orbiting Earth. What is the effect of “weightlessness” upon an astronaut who is in orbit for months? Or what about the effect of weightlessness upon plant growth? Weightlessness doesn’t mean that an astronaut is not being acted upon by the gravitational force. There is no “zero gravity” in an astronaut’s orbit. The term just means that the astronaut is in free-fall, accelerating with the acceleration due to gravity. If an elevator cable breaks, the passengers inside will be in free fall and will experience weightlessness. You can experience short periods of weightlessness in some rides in amusement parks.

Tides

Tidal forces are based on the gravitational attractive force. With regard to tidal forces on the Earth, the distance between two objects usually is more critical than their masses. Tidal generating forces vary inversely as the cube of the distance from the tide generating object. Gravitational attractive forces only vary inversely to the square of the distance between the objects. The effect of distance on tidal forces is seen in the relationship between the sun, the moon, and the Earth's waters.

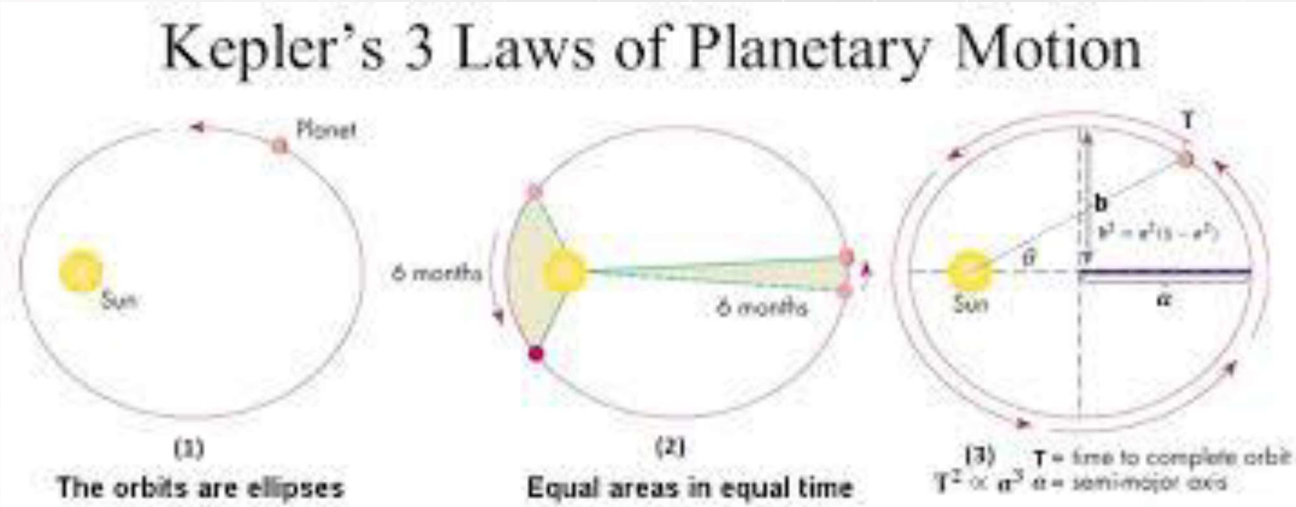


Kepler's Three Law

Kepler's Law of Orbits – The Planets move around the sun in elliptical orbits with the sun at one of the focii.

Kepler's Law of Areas – The line joining a planet to the Sun sweeps out equal areas in equal interval of time.

Kepler's Law of Periods – The square of the time period of the planet is directly proportional to the cube of the semimajor axis of its orbit.



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Additional materials

Text lectures:

Harmonic motion

http://hyperphysics.phy-astr.gsu.edu/hbase/shm.html

Gravitational field

https://openstax.org/books/college-physics/pages/6-5-newtons-universal-law-of-gravitation

Videos:

Harmonic motion

https://www.khanacademy.org/science/ap-physics-1/simple-harmonic-motion-ap

https://www.youtube.com/watch?v=Zz-9UVpYcJI

Gravitational field

https://www.khanacademy.org/science/ap-physics-1/ap-centripetal-force-and-gravitation/newtons-law-of-gravitation-ap/v/introduction-to-gravity

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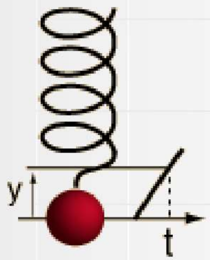
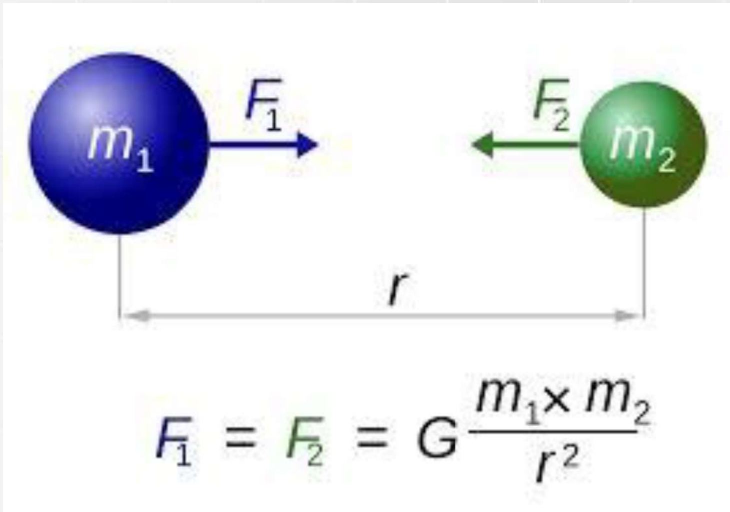
Harmonic motion and gravitational field

All right. So if you go to our website today, you will find I've assigned some problems and you should try to do them. They apply to this chapter. Then next week we'll do anothers problems connected with relativistic phenomena.





Closer look at calendar

	FEBRUARY	MARCH					APRIL				MAY					JUNE			JULY	
MON	22	1	8	15	22	29	5	12 Mon O	19	26	3	10	17	24	31	7	14	21	28	5
TUE	23	2	9	16	23	30 Fri E	6	13	20	27	4	11	18	25	1	8	15	22	29	6
WED	24	3	10	17	24	31	7	14	21	28	5	12	19	26	2 Thu E	9	16	23	30	7
THU	25	4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24	1	8
FRI	26	5	12	19	26	2	9	16	23	30	7	14	21	28	4	11	18	25	2	9
SAT	27	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12	19	26	3	10
SUN	28	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27	4	11
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Lecture
Exercise
Revision/exam

Wednesday, 18:20 - 19:50
Friday, 18:20 - 19:50

Office hours:
Monday, 20:30 - 21:30
virtual room

Quizz

Kahoot link:
https://kahoot.it/challenge/08277847?challenge-id=459c69ba-0699-474d-ae7d-12916780bd23_1616330848956

Deadline: 31st March 2021, 18:00