Licence 2
Physics
TD1

Study the following documents :

1. 8.01 Physics I

Prereq: None
Units: 3-2-7
Credit cannot also be received for 8.011, 8.012, 8.01L, 8.01T
Lecture: *MW9-11,F9* (26-152) or *MW11-1,F11* (26-152) or *MW1-3,F1* (26-152) or *MW3-5,F4* (26-152) or *TR9-11,F10* (26-152) or *TR11-1,F12* (26-152) or *TR2-4,F3* (26-152) ***+final***

Introduces classical mechanics. Space and time: straight-line kinematics; motion in a plane; forces and static equilibrium; particle dynamics, with force and conservation of momentum; relative inertial frames and non-inertial force; work, potential energy and conservation of energy; kinetic theory and the ideal gas; rigid bodies and rotational dynamics; vibrational motion; conservation of angular momentum; central force motions; fluid mechanics. Subject taught using the TEAL (Technology-Enabled Active Learning) format which features students working in groups of three, discussing concepts, solving problems, and doing table-top experiments with the aid of computer data acquisition and analysis.
T. Greytak

2. 8.02 Physics II

Prereq: Physics I (GIR), Calculus I (GIR)
Units: 3-2-7
Credit cannot also be received for 8.021, 8.022
Lecture: *MW9-11,F9* (32-082) ***+final***

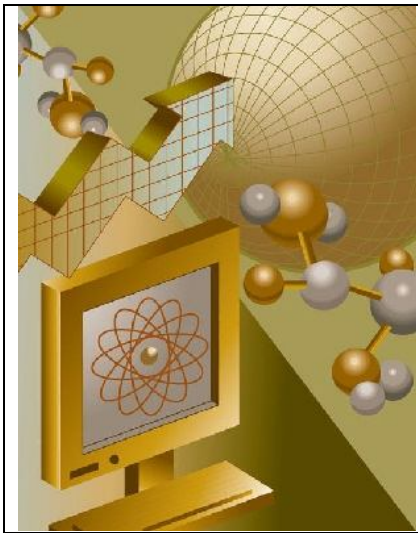
Introduction to electromagnetism and electrostatics: electric charge, Coulomb's law, electric structure of matter; conductors and dielectrics. Concepts of electrostatic field and potential, electrostatic energy. Electric currents, magnetic fields and Ampere's law. Magnetic materials. Time-varying fields and Faraday's law of induction. Basic electric circuits. Electromagnetic waves and Maxwell's equations. Subject taught using the TEAL (Technology Enabled Active Learning) studio format which utilizes small group interaction and current technology to help students develop intuition about, and conceptual models of, physical phenomena.
Fall: *E. Hudson*
Spring: *Staff*

Where were the documents taken from ? What do they have in common? Is the choice of subjects in P1 and P2 coherent? Could the syllabus of P2 be taught before P1? Which branch of maths are prerequisites in P2, and why?

Compare the definitions of physics

1. The science of matter and energy and of interactions between the two, grouped in traditional fields such as acoustics, optics, mechanics, thermodynamics, and electromagnetism, as well as in modern extensions including atomic and nuclear physics, cryogenics, solid-state physics, particle physics, and plasma physics.

2. The science of nature, or of natural objects; that branch of science which treats of the laws and properties of matter, and the forces acting upon it; especially, that department of natural science which treats of the causes (as gravitation, heat, light, magnetism, electricity, etc.) that modify the general properties of bodies; natural philosophy.



3. "Physics (Greek: physis - φύσις), in everyday terms, is the science of matter and its motion. It is the science that seeks to understand very basic concepts such as force, energy, mass, and charge. More completely, it is the general analysis of nature, conducted in order to understand how the world around us and, more broadly, the universe, behaves. Note that the term 'universe' is defined as everything that physically exists: the entirety of space and time, all forms of matter, energy and momentum, and the physical laws and constants that govern them. However, the term 'universe' may also be used in slightly different contextual senses, denoting concepts such as the cosmos, the world, and nature." (wiki)

1. **Study the drawing. In what way does it represent physics?**

2. Match and then discuss the following definitions.

Definitions of physics[1]

1. acceleration	1. A physical quantity with no direction associated with it
2. displacement	2. Motion in a straight line at constant speed
3. energy	3. A vector that describes the position of one point with respect to another one
4. field	4. The rate of change of displacement with respect to time
5. force	5. A transfer of energy as a consequence of a force acting through a distance
6. gravity	6. The rate of change of velocity with respect to time (s^{-2})
7. kinetic energy	7. A physical quantity with magnitude and direction
8. motion	8. The capacity of a system for doing work
9. potential energy	9. A physical quantity whose value is a function of spatial position
10. power	10. An influence that causes a body to change its momentum
11. scalar quantity	11. That which causes an attractive force between tow masses
12. uniform motion	12. The energy of a body due solely to its movement in space
13. vector	13. A continuing change of position
14. velocity	14. Energy stored in a system by virtue of the state of the system
15. work	15. The rate of transfer of energy between one system and another

Read the following definitions:

Gravity

Kepler's Laws of Planetary Motion:
1] Each planet moves in an elliptical orbit with the sun at one focus
2] The line form the sun to any planet sweeps out equal areas of space in equal time intervals
3] The squares of the times of revolution (days, months or years) of the planets are proportional to the cubes of their average distances from the sun**.**

Law of Universal Gravitation: Every mass in the universe attracts every other mass with a force that for two masses is directly proportional to the product of their masses and inversely proportional to the square of the distance separating them
$F = (G(m1*m2))/d^2$

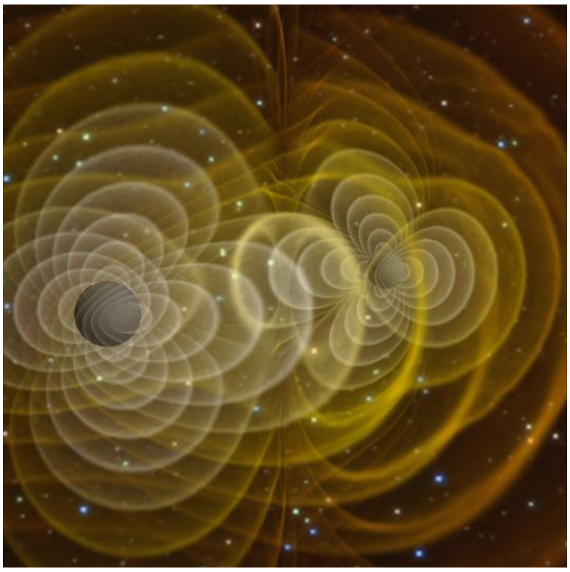
Inverse-Square Law: A law relating the intensity of an effect to the inverse square of the distance from the cause. Intensity ~ 1/distance`2
Gravity follows an inverse-square law, as do the effects of electric, magnetic, light, sound, and radiation phenomena

Weightlessness: condition wherein gravitational pull appears to be lacking.

Spring Tide: A high or low tide that occurs when the sun, earth, and moon are all lined up so that the tides due to the sun and moon coincide, making the high tides higher than average and the low tides lower than average

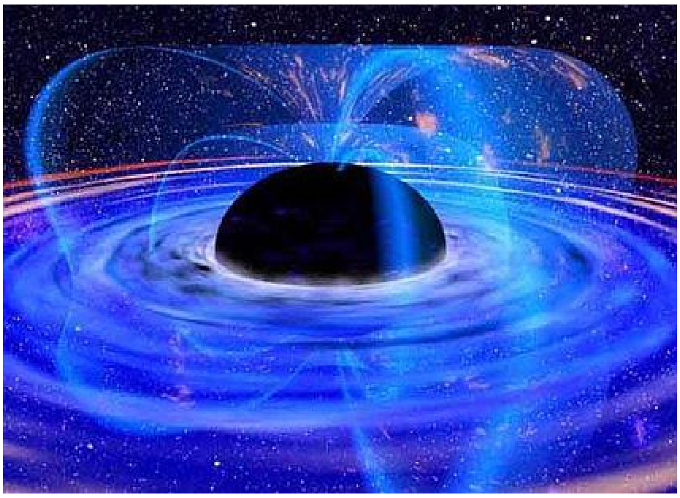
Neap Tide: A tide that occurs when the moon is midway between new and full, in either direction. Tides due to the sun and moon partly cancel, making the high tides lower and the low tides higher than average.

Gravitational Field: The space surrounding a massive body in which another mass experiences a force of attraction.



Source: nasa

Black Hole: The configuration of a massive star that has undergone gravitational collapse, in which gravitation at the surface is so intense that even the star's own light cannot escape.



Source: spacescan.org

Big Bang: The primordial explosion that is thought to have resulted in the expanding universe

Stability: In order for an object to be stable, its centre of gravity must lie directly above a point of support

The state of motion of the centre of mass in a system can only be changed by forces outside the system

Escape Speed: That speed which is sufficient to propel an object away from a planet, or any object

Tides: Tides are caused by the variation of force on the earth exerted by the moon (and the sun)
The effect of the moon is about 4 times greater than that of the sun.

Study the diagram on Kepler’s laws.

Kepler's Laws of Planetary Motion

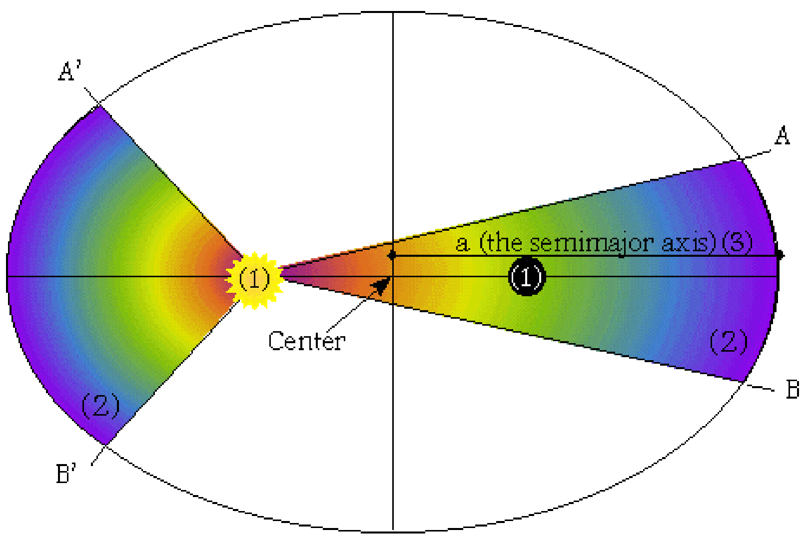
1) The orbits of the planets are ellipses with the sun as one focus. The focii are marked with a (1) on the diagram below.

2) A line from the planet to the sun sweeps over equal areas in equal intervals of time.

The planet takes just as much time to go from A' to B' as it does to go from A to B. The two rainbow areas (each marked with a (2)) have the same area.

3) A planet's orbital period squared is proportional to its average distance from the sun cubed: (orbital period)^2 = (average distance from the sun)^3
or
P^2 (in years) = a^3 (in AU)

On the diagram the semimajor axis is shown with a (3). The length of it is the average distance from the sun, so the equation uses the value of "a".



Read the following document then make a short summary and answer the questions.

Ever since physicists invented particle accelerators, nearly 80 years ago, they have used them for such exotic tasks as splitting atoms, transmuting elements, producing antimatter and creating particles not previously observed in nature. With luck, though, they could soon undertake a challenge that will make those achievements seem almost pedestrian. Accelerators may produce the most profoundly mysterious objects in the universe: black holes.

When one thinks of black holes, one usually envisions massive monsters that can swallow spaceships, or even stars, whole. But the holes that might be produced at the highest-energy accelerators--perhaps as early as 2007, when the Large Hadron Collider (LHC) at CERN near Geneva starts up--are distant cousins of such astrophysical behemoths. They would be microscopic, comparable in size to elementary particles. They would not rip apart stars, reign over galaxies or pose a threat to our planet, but in some respects their properties should be even more dramatic. Because of quantum effects, they would evaporate shortly after they formed, lighting up the particle detectors like Christmas trees. In so doing, they could give clues about how space-time is woven together and whether it has unseen higher dimensions.

A Tight Squeeze

In its modern form, the concept of black holes emerges from Einstein's general theory of relativity, which predicts that if matter is sufficiently compressed, its gravity becomes so strong that it carves out a region of space from which nothing can escape. The boundary of the region is the black hole's event horizon: objects can fall in, but none can come out. In the simplest case, where space has no hidden dimensions or those dimensions are smaller than the hole, its size is directly proportional to its mass. If you compressed the sun to a radius of three kilometers, about four-millionths of its present size, it would become a black hole. For Earth to meet the same fate, you would need to squeeze it into a radius of nine millimeters, about a billionth its present size.

Thus, the smaller the hole, the higher the degree of compression that is required to create it. The density to which matter must be squeezed scales as the inverse square of the mass. For a hole with the mass of the sun, the density is about 10^{19} kilograms per cubic meter, higher than that of an atomic nucleus. Such a density is about the highest that can be created through gravitational collapse in the present universe. A body lighter than the sun resists collapse because it gets stabilized by repulsive quantum forces between subatomic particles. Observationally, the lightest black hole candidates are about six solar masses.

Stellar collapse is not the only way that holes might form, however. In the early 1970s Stephen W. Hawking of the University of Cambridge and one of us (Carr) investigated a mechanism for generating holes in the early universe. These are termed "primordial" black holes. As space expands, the average density of matter decreases; therefore, the density was much higher in the past, in particular exceeding nuclear levels within the first microsecond of the big bang. The known laws of physics allow for a matter density up to the so-called Planck value of 10^{97} kilograms per cubic meter--the density at which the strength of gravity becomes so strong that quantum-mechanical fluctuations should break down the fabric of spacetime. Such a density would have been enough to create black holes a mere $10^{¿35}$ meter across (a dimension known as the Planck length) with a mass of $10^{¿8}$ kilogram (the Planck mass).

This is the lightest possible black hole according to conventional descriptions of gravity. It is much more massive but much smaller in size than an elementary particle. Progressively heavier primordial black holes could have formed as the cosmic density fell. Any lighter than 10^{12} kilograms would still be smaller than a proton, but beyond this mass the holes would be as large as more familiar physical objects. Those forming during the epoch when the cosmic density matched nuclear density would have a mass comparable to the sun's and so would be macroscopic. Scientific American

Questions

1. What exactly is a black whole?
2. How are they produced?
3. Who first imagined black holes?
4. How do particles react when confronted with a black hole?
5. How could they be artificially produced by man?

Fill in the missing words:

The high ……………….of the early universe were a prerequisite for the formation of primordial black holes but did not guarantee it. For a region to stop ……………….and collapse to a black hole, it must have been denser than average, so density fluctuations were also necessary. Astronomers know that such …………….. existed, at least on large scales, or else structures such as galaxies and clusters of galaxies would never have coalesced. For primordial black holes to ………….., these fluctuations must have been stronger on smaller scales than on large ones, which is possible though not inevitable. Even in the absence of fluctuations, holes might have formed spontaneously at various cosmological phase transitions--for example, when the universe ended its early ………… of accelerated expansion, known as inflation, or at the nuclear density epoch, when particles such as protons condensed out of the soup of their constituent quarks. Indeed, cosmologists can place important constraints on models of the early universe from the fact that not too much …………. ended up in primordial black holes.

Study the following:
A neutron walks into a bar; he asks the bartender, 'How much for a beer?' The bartender looks at him, and says 'For you, no charge.'
Two fermions walk into a bar. One orders a drink. The other says 'I'll have what he's having.'
Two atoms bump into each other. One says 'I think I lost an electron!' The other asks, 'Are you sure?', to which the first replies, 'I'm positive.''
Where does bad light end up? Answer: In a prism!
Heisenberg is out for a drive when he's stopped by a traffic cop. The cop says 'Do you know how fast you were going?' Heisenberg says 'No, but I know where I am.'
Source: physlink.com

KEY

acceleration	**The rate of change of velocity with respect to time (s^{-2})**
displacement	**A vector that describes the position of one point with respect to another one**
energy	**The capacity of a system for doing work**
field	**A physical quantity whose value is a function of spatial position**
force	**An influence that causes a body to change its momentum**
gravity	**That which causes an attractive force between tow masses**
kinetic energy	**The energy of a body due solely to its movement in space**
motion	**A continuing change of position**
potential energy	**Energy stored in a system by virtue of the state of the system**
power	**The rate of transfer of energy between one system and another**
scalar quantity	**A physical quantity with no direction associated with it**
uniform motion	**Motion in a straight line at constant speed**
vector	**A physical quantity with magnitude and direction**
velocity	**The rate of change of displacement with respect to time**
work	**A transfer of energy as a consequence of a force acting through a distance**

Densities; expanding, fluctuations, form, period, matter