SPASH ASTRONOMY
CHAPTER 4: GRAVITY AND THE CONQUEST OF SPACE
OVERHEAD LECTURE NOTES

1. What are two ways to explore our space environment?

There are two ways to explore our space environment. We can actually **go there** (this chapter), or we can **interpret light signals coming from there**(next chapter).

2. When did we start dreaming of actually trying to go to the moon?
In 190 A.D., Greek satirist Lucian had one of his characters put on vulture and eagle wings, take off from Mr. Olympus, and fly to the Moon to learn how the stars came to be "scattered up and down the heavens carelessly."

Over a hundred fictional descriptions of voyages to the Moon were published in Europe **between** 1493 and 1783, when the first balloon ascensions were made (Nicholson, 1949).

3. What did Isaac Newton show about the gravitational force of the moon?
Whereas the Moon is 60 times farther than the Earth's surface from the Earth's center, its **gravitational acceleration is about 1/3600**, or $1/60^2$, of the acceleration experienced at **the Earth's** surface. (inverse square law)

4. Name three other inverse square law relationships?
Light, radio waves, water spray, paint spray, from a fast-rotating sprinkler, magnetism, and sound are all examples.

5. Define the following words: circular velocity, escape velocity, and hyperbolic velocity, apogee, perigee, ellipse,?

The speed at which an object must move parallel to the surface of a body in order to stay in circular orbit around it - is called the **circular velocity**.

The unique speed, which allows an object to escape the Earth forever, is called the **escape velocity**. At a point near the surface of the Earth, the escape velocity is about 11 km/s; it is less at more distant points. Launched at a still higher speed, a body travels a similar curve called a hyperbola and does not return. Thus a launch speed exceeding escape velocity is called a **hyperbolic velocity**.

An orbiting body's closest point to the Earth is called its **perigee**; its farthest point is its **apogee**. As a body is launched at higher and higher speeds, the apogee point is farther and farther away. Each orbit is an **ellipse** - a type of curve describing the closed orbit of one body around a second body.

6. How do rockets work?
Rockets work essentially by **Newton's third law** of motion: For every action, there is an equal and opposite reaction. The force used to expel high-velocity gases out the back of a rocket nozzle pushes the rocket forward with equal force. This force is called **thrust**.

7. Who was **Wernher von Braun**?

In the 1920s in Germany, Hermann Oberth, who remarked that Verne's book was an inspiration, published several books on rocket-powered space travel. Oberth's work attracted a group of enthusiasts, including **Wernher von Braun**, whose astronautical experiments were converted into the V-2 guided missile program under the Nazis. At the end of World War II, about 125 German rocket experts, including **von Braun**, moved to the United States and continued the chain of space-travel development that stretches back to Lucian, Newton, and Verne. Note: Oberth was a NASA guest at the first successful Moon flight launch in 1969.

8. What is the story behind U.S.A. first satellites, who designed them, what was there mission, what did they discover?
President Eisenhower announced in 1955 that the United States would launch a satellite during the International Geophysical Year (1957-58). This was to be a civilian program using a nonmilitary rocket called Vanguard. Within days, Soviet scientists announced their plan to launch satellites larger than the American one. This plan was not taken seriously in the West: Americans viewed the Soviets as the Soviets portrayed themselves in their poster art - **as unsophisticated, shirtsleeved tractor drivers.**
On **October 4, 1957**, the Soviet Union astonished the world by launching the first artificial satellite, the 83 Kg(184 lb) instrumented sphere, pictured on page 80, was named **Sputnik I** (Russian for "satellite"). In Nov. the half-ton Sputnik II went up, carrying a dog as a biological test (pictured on page 81).

In Dec., under hasty orders, millions watched on live TV as USA's first rocket effort blew up on the launch pad.
After years of chafing at the bit, the Army team under von Braun was given the go-ahead in Nov.; 84 days later, on Jan. 31, 1958, the first American satellite, Explorer I, was orbited. Vanguard I, a 1.5 kg (3 lb) sphere, went into orbit in March.

Sputnik III went up in May. At 1.5 tons, it was 56 times as massive as the three US satellites combined.

The first satellites were designed primarily to probe the nearby environment of space. Among their discoveries were the Van Allen belts (doughnut-shaped zones of energetic atomic particles surrounding Earth).

9. Who were the first and second men in space and when did they go up?
American engineers concentrated on miniaturizing precision instruments, while Soviet engineers, lacking the technology to miniaturize, concentrated on rocket power.

On April 12, 1961, in a 5 ton craft, a 27 year old Russian, Yuri Gagarin, became the first person to orbit the Earth, which he did in 108 min.

The first US manned rocket flight was Alan Shepard's 15 min suborbital flight on May 5, 1961. On Aug. 7, Russian cosmonaut Gherman Titov made 17 orbits in a full-day flight. America's first single-orbit flight came 6 months later on Feb. 20, 1962, when John Glenn piloted a Mercury capsule.

10. What is the story behind the decision to explore the moon?

Space exploration obviously has not been a purely scientific effort divorced from politics. The pacing of the whole enterprise has been determined by social judgments about national prestige and by funding decisions.

President Kennedy, who took office in Jan. 1961, sought national goals that would spur creative effort, he was at first skeptical about a lunar program (since Russia was in the lead), but he remarked: "If you had a scientific spectacular on this earth that would be more useful >>> or something that is just as dramatic and convincing as space, then we would do it." We talked about a lot of things ... and the answer was that you couldn't make another choice.

So on May 25, 1961, the goal was set in an extraordinary presidential speech before Congress: "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to earth."

After Kennedy's assassination in Nov. 1963, the NASA program, especially the Apollo Moon-landing program became almost a memorial to the president. This prevented funding cutbacks until the program was completed. After the sixth successful landing, in 1972, a few proposed additional landings were canceled, and funding for planetary exploration began a long-term decline.

11. Name at least three space related U.S. accomplishments from 1975 to 1992?

1). In 1975, the last remaining Apollo, carrying three American astronauts, linked in orbit with a Russian Soyuz spacecraft carrying two cosmonauts. The explorers shared good-humored handshakes, conducted mutual experiments, and televised pictures of each others' countries to audiences below in a gesture of goodwill.

2). In the 1970s and 1980s, both countries experimented with temporary space stations occupied intermittently by astronauts.

3). Both countries also launched successful probes to other planets during the 70s and 80s. (All the planets except Pluto)

4). In the cases of Venus and Mars, robotic probes have also landed on the surfaces, sending back photos and environmental data.

5). American engineers developed a fleet of four Space Shuttles (Columbia, Challenger, Endeaver, Discovery) intended to meet most of the nation's launch needs. The first 24 flights, from 1981 through 1985, were highly successful. However, in 1986, during the 25th shuttle launch, disaster struck. An explosion destroyed the shuttle Challenger, killing the racially mixed crew of two women and five men.

6). After a two year delay, subsequent missions included the 1989 launch of the Magellan probe, which has mapped the surface of Venus; the 1989 launch of the Galileo probe, which has made the first close-up photos of an asteroid and is continuing on toward Jupiter (a flight marred by a stuck antenna that will limit data).

7). And the 1991 launch of the largest astronomical telescope in orbit, the Hubble Space Telescope.

8). In 1992, a replacement shuttle brought the U.S. fleet back to four spaceships.

9). By the early 90s, the U.S. Department of Defense had more funding for space operations than all of NASA; most of it was secret and nonscientific. Development of the Strategic Defense Initiative ("Star Wars") program was cut back after the end of the cold war.
10). Congress declined to fund an American mission to Halley's comet; that enterprise was carried out in 1986 by probes from Europe, the USSR, and Japan.

11). 1992 saw the successful American launch of a new probe to Mars, but the 1992 congressional budget debate canceled the in-progress development of an advanced American probe to a comet.

12). The administration also proposed turning off a successful probe in orbit around Venus before its useful life was over, in order to save money.

12. Name at least two Soviet space achievements since 1975.

1). In 1986 they launched the first module of the Mir space station, which was expanded to a very large size in following years by the addition of several more modules.

2). Russian cosmonauts have lived in Mir for more than a year at a time - a period long enough to fly to Mars.

3). In 1987 Soviet engineers launched the world's largest rocket booster, Energia, and also a shuttle of their own.

4). In 1989 they carried out a partially successful robotic mission to Mars' moon, Phobos.

13. What did NASA cost from 1959-69?
The total NASA expenditure (including aircraft development as well as space research) was $35 billion, or about 2.5% of the total budgeted U.S. expenditures. During the buildup of the military and the deficit under Pres. Reagan, the NASA budget dropped to only about 1% of the total budget, where it remained through the early 1990s.

14. List at least four practical results of the space programs:

1). With our current weather satellite system we can monitor weather constantly. Two generations ago we couldn't predict hurricanes and now we can evacuate in time.

2). Another benefit is the communications satellite. Because satellites at this altitude revolve around Earth with an orbital period of 24 hours, they stay above the same spot on Earth. That's why backyard TV dish antennas can be pointed at a fixed spot in the sky.

3). use of satellites to improve mapping, detect mineral deposits and archaeological sites, and perhaps most importantly, provide improved monitoring of environmental problems.

4). To keep cost down, we are funding future projects in astronomy, space exploration, and science generally with other countries, which may have an unexpected social benefit.

5). Our computer technology sprang out of the space program.

6). Microwave ovens.

15. List three intangible results of the space program:
1). It creates a cosmic perspective. When astronauts brought back the first pictures of Earth seen from a large distance as a globe hanging in empty space, forcing a dramatic realization that we share the same finite globe.
2). Space exploration provides a frontier and a sense of adventure that is important to human well-being.
3). Spaceflight offers the theoretical prospect to escape from natural or manmade disasters that might befall the Earth.

June 2006

16. Choose any 2 missions from each category. For 10 points each, research up to any 5 of these missions and turn in a one page paper listing the missions and their dates/purpose. Refer to website http://science.hq.nasa.gov/missions/phase.html.

Under Study	Development	Operating	Operating	Past	Past
Con. X	AIM	ACE	MGS	ASCA	NEAR
Geospace	Aquarius	ACRIMSAT	MRO	Astro-1	ORFEUS
Glory	CINDI	Aqua	New Horizons	Astro-2	Pioneer 10,11
GOES-R	Dawn	Aura	NMP EO-1	BBXRT	Pioneer Venus
GPM	GLAST	CALIPSO	Odyssey	CGRO	POES L
IBEX	GOES N,O,P	Cassini	Polar	Clementine	POES M
JDEM	Herschel	CHAMP	QuikSCAT	COBE	Ranger
Juno	Kepler	Chandra	RHESSI	CONTOUR	ROSAT
JWST	NPP	CHIPS	Rosetta	CRRES	SAC-B
LDCM	OCO	CloudSat	RXTE	DE-1	SAMPEX
LISA	Phoenix	Cluster	SOHO	DS 1	SNOE
MMS	Planck	Deep Impact	SORCE	DS 2	Spartan
MSL	POES N,N'	FAST	Spitzer	DXS	Surveyor
OSTM	SDO	FUSE	ST-5	Equator-S	SRTM
Sentinels	SOFIA	GALEX	Stardust	ERBS	Starshine
SIM	Solar-B	Geotail	Suzaku	EUVE	SWAS
ST-8	ST-6	GP-B	Swift	Galileo	TERRIERS
ST-9	ST-7	GRACE	Terra	Genesis	TOPEX/Poseidon
WISE	STEREO	HETE-2	TIMED	GOES L	TSS-1
	THEMIS	HST	TOMS-EP	GOES M	TSS-1R
	TWINS	IceSAT	TRACE	HALCA	UARS
		INTEGRAL	TRMM	Hipparcos	VLBI
		Jason	Ulysses	IEH-3	Viking
		Landsat 7	Voyager	IMAGE	WIRE
		Mars Express	Wind	IMP-8	Yohkoh
		Mars Rovers	WMAP	IRTS	
		MESSENGER	XMM-Newton	ISEE-3/ICE	
		Meteor 3M		ISO	
				IUE	
				KAO	
				Leonid MAC	
				Lunar Pros.	
				Magellan	
				Mariner	
				MCO	
				Mars Obs.	
				Mars Path.	
				MPL	