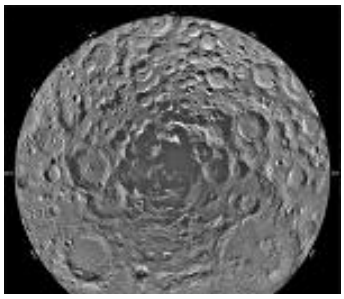
Lunar CRater Observation and Sensing Satellite

Inelastic Collisions

Will the Moon be Hurt by the Impact of the LCROSS Spacecraft?

When the LCROSS spacecraft sends the upper stage of the Centaur rocket, which has the mass of a sports utility vehicle, to the south pole of the Moon, will the Moon's orbit be affected? No, because the mass of the Centaur stage is tiny compared to the mass of the Moon. Natural objects much more massive than the Centaur rocket, and with much greater kinetic energy[1], impact the Moon all the time. Craters form on the Moon as a result, and the Moon's orbit is not noticeably affected. How can we prove that the impact of the Centaur rocket on the Moon will not affect the Moon's orbit?

When two objects collide and bounce off of one another, kinetic energy, the energy of motion, is conserved in the collision. That means the total amount of kinetic energy is the same before and after the collision. Momentum, a force which moves objects forward against resistance such as air, is also conserved in elastic collisions. Elastic collisions are when two bodies collide and bounce off one another after the collision, without permanently deforming or losing energy in some other way.



The South Pole of the Moon. The Moon is a heavily cratered body which has been bombarded by impacts for billions of years. Photo: courtesy NASA

When the upper stage of the Centaur rocket impacts the Moon, it will excavate material on the Moon and remain there. This is known as a completely inelastic collision. An inelastic collision is one in which two colliding objects stick together after the collision. In an inelastic collision, kinetic energy is lost but momentum is conserved.

Conservation of energy is a fundamental concept of physics. Energy can neither be created nor destroyed; it can only be converted from one form to another. LCROSS scientists are depending upon this conversion of kinetic energy to other forms such as thermal energy[2] to observe the plume and the thermal flash[3] that will result from the collision.

Because the total momentum remains the same, however, the velocity[4] of the two objects moving together after the collision can be readily computed. As a general rule in collisions, when the masses of the colliding objects differ greatly, such as the mass[5] of the Moon and the Centaur rocket, the effects are much less on the more massive object. In fact, the change in the Moon's velocity due to the collision of the Centaur rocket can be computed to be approximately 8×10^{-20} kilometers per second. This is the number 8 with nineteen zeros in front of it before the decimal place. This number or change in the velocity of the Moon in its orbit due to the collision with the Centaur rocket is essentially zero. The collision of the Centaur rocket with the Moon will produce no change in the Moon's orbit.

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1 - Kinetic energy: the energy an object has because of its motion. 2: Thermal energy - the energy that is related to or caused by heat. 3: Thermal flash - the light flash due to thermal heating. 4: Velocity - the direction and speed of an object. 5: mass - a measure of the total amount of material in a body, defined either by the inertial properties of the body or by its gravitational influence on other bodies.