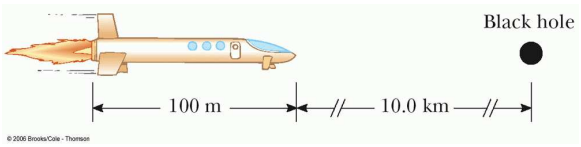
Shooting the Sun - 2

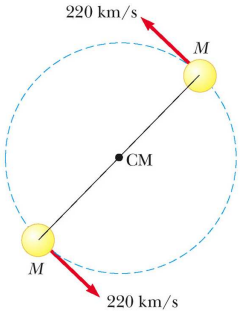
1. During a solar eclipse, the Moon, the Earth, and the Sun all lie on the same line with the Moon between the Earth and the Sun. What is the force exerted on the Moon by the Sun? What is the force exerted on the Moon by the Earth? What is the force exerted on the Earth by the Sun?

2. A student proposes to measure the gravitational constant G by suspending two spherical objects from the ceiling of a tall cathedral and measuring the deflection of the cables from the vertical. Draw a free-body diagram of one of the objects. If two objects of mass $m_1 = 100\ kg$ are suspended at the lower ends of two cables of length $L = 45\ m$ and the cables are attached to the ceiling a distance $l = 1\ m$ apart, then what is the separation s of the objects? (Hints: The difference between s and l will be very small and *Mathematica* may be helpful here.

3. On the way to the Moon the *Apollo* astronauts passed a point where the Moon's gravitational pull became stronger that the Earth's pull. What is the distance of this point from the Earth? What is the acceleration due to Earth's gravity at this point?

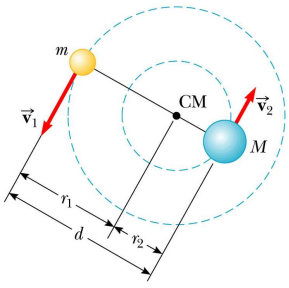
4. A spacecraft in the shape of a long cylinder has length $L = 100\ m$ and mass $m = 1000\ kg$ (see below left). It has strayed too close to a black hole with mass m_b that is 100 times that of the Sun. The nose of the spacecraft points toward the black hole and the distance between the nose and the black hole's center is $r_1 = 10^4\ m$. What is the total force on the spacecraft? What is the difference in the acceleration of the nose of the ship and the tail?





5. Plaskett's binary system consists of two stars that revolve in a circular orbit about a center of mass midway between them so the two masses are equal (see figure above right). Assume the orbital speed is $v_o = 2.2 \times 10^5\ m/s$ and the orbital period is $T = 14.4\ d$. What is the mass M of each star? Compare with the Sun.

6. Two stars of mass M and m separated by a distance d follow circular orbits about their center of mass (see figure). Show that each star has period given by the following.



$$T^2 = \frac{4\pi^2 d^3}{G(M+m)}$$