This print-out should have 14 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering. The due time is Central time.

Apollo 11 in Orbit 01

14:09, trigonometry, numeric, > 1 min, normal.

001

When it orbited the Moon, the *Apollo 11* spacecraft's mass was 9979 kg, and its mean distance from the Moon's center was 1.85099×10^6 m. Assume its orbit was circular and the Moon to be a uniform sphere of mass 7.36×10^{22} kg.

Given the gravitational constant G is 6.67259×10^{-11} N m^2/kg^2, calculate the orbital speed of the spacecraft. Answer in units of m/s.

002

What is the minimum energy required for the craft to leave the orbit and escape the Moon's gravitational field? Answer in units of J.

Attraction in Space Shuttle

14:03, trigonometry, numeric, > 1 min, wording-variable.

003

Earth's gravitational field is 7.83 N/kg at the altitude of the space shuttle.

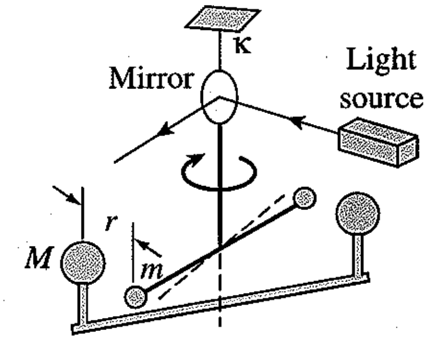
What is the size of the force of attraction between a student of mass 45 kg and Earth? Answer in units of N.

Finding Gravitational Force 02

14:01, trigonometry, numeric, > 1 min, normal.

004

An apparatus like the one Cavendish used to find G has large lead balls that are 5.9 kg in mass and small ones that are 0.047 kg. The center of a large ball is separated by 0.055 m from the center of a small ball.



The Cavendish apparatus for measuring G. As the small spheres of mass m are attracted to the large spheres of mass M, the rod between the two small spheres rotates through a small angle.

Find the magnitude of the gravitational force between the masses if the value of the universal gravitational constant is 6.67259×10^{-11} N m^2/kg^2. Answer in units of N.

Falling Meteor

14:03, trigonometry, numeric, > 1 min, normal.

005

When a falling meteor is at a distance 3 times the radius of the Earth above the Earth's surface, what is its free fall acceleration? The acceleration of gravity is 9.8 m/s^2, the universal gravitational constant is 6.67259×10^{-11} N $\cdot$ m^2/kg^2, and the Earth's radius is 6.37×10^6 m.

Answer in units of m/s^2.

Cylindrical Habitat in Space

14:03, trigonometry, numeric, > 1 min, normal.

006

A cylindrical habitat in space 6 km in diameter and 30 km long has been proposed (by G.K. O'Neill, 1974). Such a habitat would have cities, land, and lakes on the inside surface and air and clouds in the center. This would all be held in place by rotation of the cylinder about its long axis.

How fast would the cylinder have to rotate to imitate the Earth's gravitational field at the walls of the cylinder? The acceleration of gravity is 9.8 m/s^2.

Answer in units of rad/s.

Two Spheres Collision SW

14:07, trigonometry, numeric, > 1 min, normal.

007

Given: $G = 6.67259 \times 10^{-11}\ \mathrm{N\,m^2/kg^2}$

Two spheres have equal radius $R = 12.45$ m and mass $m = 1200$ kg. Their centers are separated a distance $4R$. The spheres are released from rest. What will be their speed when they collide? Answer in units of m/s.

Shooting a Rocket Upward

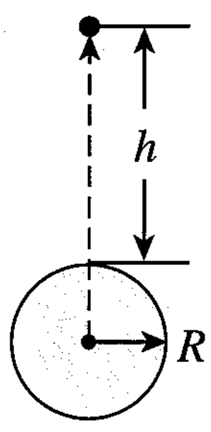
14:09, trigonometry, numeric, > 1 min, normal.

008

For this problem, we assume that we are on Planet-I. The radius of this planet is R =3200 km, the gravitational acceleration at the surface is g_I =2.5 m/s^2, and the gravitational constant $G = 6.67 \times 10^{-11} N\,m^2/kg^2$ in SI units. The mass of Planet-I is not given. Not all the quantities given here will be used.

Suppose a cannon ball of mass $m = 5000$ kg is projected vertically upward from the surface of this planet. It rises to a maximum height h =6400 km above the surface of the planet.

Caution: Here the gravitational acceleration decreases as the cannon ball travels away from Planet-I.



Determine the kinetic energy (in Joules) of the cannon ball immediately after it is fired off. Answer in units of J.

Decaying Orbit 02

14:09, trigonometry, numeric, > 1 min, normal.

009

Given:

$$M_{earth} = 5.98 \times 10^{24}\ \mathrm{kg}$$
$$R_{earth} = 6.37 \times 10^{6}\ \mathrm{m}$$

A satellite of mass 500 kg is in a circular orbit at an altitude of 500 km above the earth's surface. Because of air friction, the satellite eventually is brought to the earth's surface, it hits the earth with a velocity of 2 km/s. Let the gravitational potential energy be zero at $r = \infty$. The universal gravitational constant $G = 6.67259 \times 10^{-11}\ \mathrm{N\,m^2/kg^2}$.

What is the total energy of the satellite in orbit? Answer in units of J.

010

What is the total energy of the satellite just before it hits the ground? Answer in units of J.

011

What is the work done by friction? Answer in units of J.

Force Exerted by a Sphere

14:11, trigonometry, numeric, > 1 min, normal.

012

Given: $G = 6.67259 \times 10^{-11}\ \mathrm{N\,m^2/kg^2}$

A 500 kg uniform solid sphere has a radius of 0.4 m.

Find the magnitude of the gravitational force exerted by the sphere on a 50 g particle located 1.5 m from the center of the sphere. Answer in units of N.

013

Find the magnitude of the gravitational force exerted by the sphere on a 50 g particle located at the surface of the sphere. Answer in units of N.

014

Find the magnitude of the gravitational force exerted by the sphere on a 50 g particle located 0.2 m from the center of the sphere.

Answer in units of N.