

Lesson 1 – Gravitational Fields

1. If a rocket is given a great enough speed to escape from Earth, could it also escape from the Sun and, hence, the solar system? What happens to the artificial Earth satellites that are sent to explore the space around distant planets, such as Neptune?
2. Assuming that a rocket is aimed above the horizon, does it matter which way it is aimed for it to escape from Earth? (Neglect air resistance.)
3. Determine the elevation in kilometres above the surface of Uranus where the gravitational field strength has a magnitude of 1.0 N/kg .
4. Ganymede, one of Jupiter's moons discovered by Galileo in 1610, has a mass of $1.48 \times 10^{23} \text{ kg}$. What is the magnitude of Ganymede's gravitational field strength at a point in space $5.55 \times 10^3 \text{ km}$ from its centre?
5. Determine the total gravitational field strength (magnitude and direction) of the Earth and Moon at the location of the spacecraft in **Figure 1**.
10. A 4.60-kg rocket is launched directly upward from Earth at 9.00 km/s .
 - (a) What altitude above Earth's surface does the rocket reach? Assume the rocket is orbiting at that altitude
 - (b) What is the rocket's binding energy at that altitude?
11. Titan, a moon of Saturn discovered by Christian Huygens in 1655, has a mass of $1.35 \times 10^{23} \text{ kg}$ and a radius of $2.58 \times 10^3 \text{ km}$. For a $2.34 \times 10^3\text{-kg}$ rocket, determine
 - (a) the escape speed from Titan's surface
 - (b) the escape energy of the rocket
12. A rocket ship of mass $1.00 \times 10^4 \text{ kg}$ is located $1.00 \times 10^{10} \text{ m}$ from Earth's centre.
 - (a) Determine its gravitational potential energy at this point, considering only Earth.
 - (b) How much kinetic energy must it have at this location to be capable of escaping from Earth's gravitational field?
 - (c) What is its escape speed from Earth at this position?

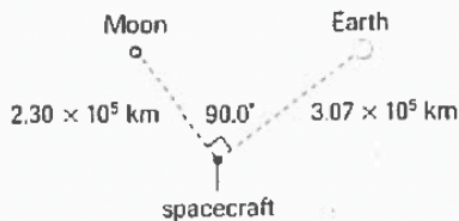


Figure 1

6. Mercury has both a surface gravitational field strength and a diameter 0.38 times the corresponding Earth values. Determine Mercury's mass.
7. A satellite in a circular orbit around Earth has a speed of $7.15 \times 10^3 \text{ m/s}$. Determine, in terms of Earth's radius,
 - (a) the distance the satellite is from Earth's centre
 - (b) the altitude of the satellite
8. Tethys, one of Saturn's moons, travels in a circular orbit at a speed of $1.1 \times 10^4 \text{ m/s}$. Calculate
 - (a) the orbital radius in kilometres
 - (b) the orbital period in Earth days

2. A satellite of mass 225 kg is located 8.62×10^6 m above Earth's surface.
 - (a) Determine the magnitude and direction of the gravitational force on the satellite.
 - (b) Determine the magnitude and direction of the resulting acceleration of the satellite.
 3. Determine the magnitude and direction of the gravitational field strength at a point in space 7.4×10^7 m from the centre of Earth.
 4. A 6.2×10^2 -kg satellite above Earth's surface experiences a gravitational field strength of magnitude 4.5 N/kg.
 - (a) Knowing the gravitational field strength at Earth's surface and Earth's radius, how far above Earth's surface is the satellite? (Use ratio and proportion.)
 - (b) Determine the magnitude of the gravitational force on the satellite.
 6. A 456-kg satellite in circular orbit around Earth has a speed of 3.9 km/s and is 2.5×10^7 m from Earth's centre.
 - (a) Determine the magnitude and direction of the acceleration of the satellite.
 - (b) Determine the magnitude and direction of the gravitational force on the satellite.
 7. (a) On the surface of Titan, a moon of Saturn, the gravitational field strength has a magnitude of 1.3 N/kg. Titan's mass is 1.3×10^{23} kg. What is the radius of Titan in kilometres?
 - (b) What is the magnitude of the force of gravity on a 0.181-kg rock on Titan?
 8. Given that Earth's surface gravitational field strength has a magnitude of 9.80 N/kg, determine the distance (as a multiple of Earth's radius r_E) above Earth's surface at which the magnitude of the field strength is 3.20 N/kg.
1. How does the escape energy of a 1500-kg rocket compare to that of a 500-kg rocket, both initially at rest on Earth?
 2. Do you agree or disagree with the statement, "No satellite can orbit Earth in less than about 80 min"? Give reasons. (*Hint:* The greater the altitude of an Earth satellite, the longer it takes to complete one orbit.)
 3. A space shuttle ejects a 1.2×10^3 -kg booster tank so that the tank is momentarily at rest, relative to Earth, at an altitude of 2.0×10^3 km. Neglect atmospheric effects.
 - (a) How much work is done on the booster tank by the force of gravity in returning it to Earth's surface?
 - (b) Determine the impact speed of the booster tank.
 4. A space vehicle, launched as a lunar probe, arrives above most of Earth's atmosphere. At this point, its kinetic energy is 5.0×10^9 J and its gravitational potential energy is
 5. An artificial Earth satellite, of mass 2.00×10^3 kg, has an elliptical orbit with an average altitude of 4.00×10^2 km.
 - (a) What is its average gravitational potential energy while in orbit?
 - (b) What is its average kinetic energy while in orbit?
 - (c) What is its total energy while in orbit?
 - (d) If its perigee (closest position) is 2.80×10^2 km, what is its speed at perigee?
 6. A 5.00×10^2 -kg satellite is in circular orbit 2.00×10^2 km above Earth's surface. Calculate
 - (a) the gravitational potential energy of the satellite
 - (b) the kinetic energy of the satellite
 - (c) the binding energy of the satellite
 - (d) the percentage increase in launching energy required for the satellite to escape from Earth