Student #: _____ Student Name: _____

Physics 12 Homework Unit 3: Motion in Space

(Plus a few questions from Units 1 & 2)

1. While hiking in the wilderness, you come to the top of a cliff that is $60.0\,\mathrm{m}$ high. You throw a stone from the cliff, giving it an initial velocity of $75.6\,\mathrm{km/h}$ at 35° above the horizontal. How far from the base of the cliff does the stone land?

2. You want to shoot a stone with a sling shot and hit a target on the ground $14.6\,\mathrm{m}$ away. If you give the stone an initial speed of $12.5\,\mathrm{m/s}$, neglecting friction, what is/are the launch angle(s) in order for the stone to hit the target? What would be the maximum height(s) by the stone? What would be its time of flight? Assume motion is symmetric.

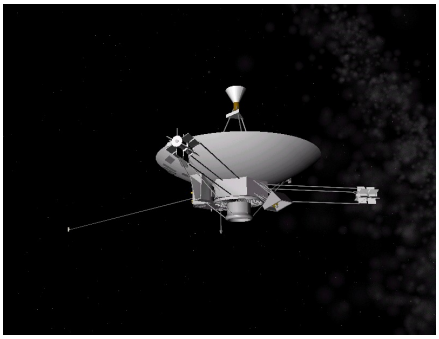
3. A boy is twirling a $555\,\mathrm{g}$ ball on a $0.65\,\mathrm{m}$ string in a *horizontal* circle. The string will break if the tension reaches $15\,\mathrm{N}$.

   (a) Draw a free-body diagram on the ball and indicate all forces acting on it.
   (b) What is the centripetal force when tension is at maximum?
   (c) What is the maximum speed at which the ball can move without breaking the string?

4. A car exits a highway on a ramp that is banked at 15° with a radius of curvature of $65\,\text{m}$. If the ramp is extremely icy and the driver cannot depend on any friction to help make the turn, what is the maximum speed that the driver can travel so that the car will not skid off the ramp?

5. A highway curve with a radius of curvature of $155\,\text{m}$ must accommodate cars travelling at $115\,\text{km/h}$ without friction. What is the least measure of the angle should the curve be banked?

6. **DEEP SPACE EXPLORATION:** The Pioneer 10 Spacecraft was the first to journey beyond Jupiter and is now well past Pluto. To escape from the solar system, how fast did Pioneer 10 have to be travelling as it passed the orbit of Jupiter? Assume that the mass of the solar system is essentially concentrated at the Sun. The radius of Jupiter's orbit is $7.78 \times 10^{11}\,\text{m}$.



7. Saturn has a mass of $5.7 \times 10^{26}\,\text{kg}$ and a radius of $6.0 \times 10^{7}\,\text{m}$. What is the maximum speed of a satellite in a circular orbit around Saturn?

8. A 1.00×10^2 kg space probe is in a circular orbit, 25 km above the surface of Titan, a moon of Saturn. If the radius of Titan is 2575 km and its mass is 1.346×10^{23} kg, determine the space probe's:
   (a) Orbital kinetic energy
   (b) Orbital speed
   (c) Orbital period
   (d) Orbital gravitational potential energy
   (e) Total orbital energy
   (f) Binding energy (Binding energy is the negative of the total energy)
   (g) Additional speed required for the space probe to break free from Titan

   (Hint: Some parts of this question do not require additional calculations.)

9. Determine the thrust produced if 1.50×10^3 kg of gas exit the combustion chamber each second, with a speed of 4.00×10^3 m/s.

10. We can calculate the total orbital energies of *any* object orbiting the Earth, including space dust, satellites, the ISS, and of course the moon, the largest natural "satellite" orbiting Earth. Calculate the Moon's kinetic, gravitational and total energies while in orbit around Earth.

11. A $550\,\text{kg}$ satellite launched upward from Earth's surface reaches an orbit at a height of $6000\,\text{km}$. Find
    (a) its change in gravitational potential energy
    (b) its orbital kinetic energy
    (c) its initial kinetic energy

    (Hint: gain in U_g is loss in K)

12. A $20\,000\,\text{kg}$ meteorite from outer space ($r = \infty$) is headed directly towards Earth with a speed of $3.0\,\text{km/s}$. Find its speed when it is $200\,\text{km}$ above Earth's surface. (Hint: use the conservation of energy.)

13. At what location from Earth are the gravitational forces of Earth and the Moon balanced?

14. A communications satellite that is in geosynchronous orbit above Earth's equator.
    (a) What is the orbital period in seconds?
    (b) What is the satellite's orbital speed?
    (c) What is the altitude of the satellite?

15. The Apollo Project was the first to put American astronauts on the moon. In total, six spacecrafts landed the moon in the 1960s. During the mission, the Apollo "Command Module" (CM) would typically stay in an orbit $110\,\mathrm{km}$ above the lunar surface.
    (a) Given the orbital altitude, how long would it take for the CM to complete one orbit around the Moon? What is its speed in orbit?
    (b) During the mission, the CM has to decrease its altitude to a mere $11\,\mathrm{km}$ orbit above the lunar surface so that the "Lunar Module" (LM) can be safely detached from it. How much energy is released during the descent? The combined mass of the CM and the CM is $28\,000\,\mathrm{kg}$.
    (c) How fast would the CM be moving at this low altitude?
    (d) In order to return to Earth, the CM needs to break free from Moon's gravitational pull. What is the escape speed at this altitude?

16. When the space shuttle delivers a crew to the International Space Station, it usually boosts the orbit of the station from about $320\,\text{km}$ to $350\,\text{km}$. How much energy does the shuttle add to the station's orbit? (The mass of the ISS is approximately $4.20 \times 10^5\,\text{kg}$.)