Gravitational Potential Energy & General Relativity

Pre-Lecture Questions

Problem Set #39 (due next time)

Lecture Outline

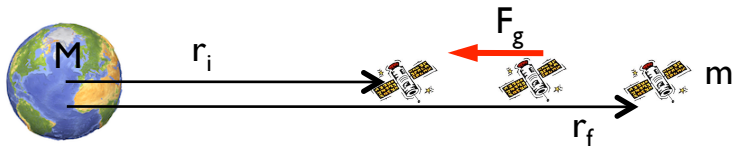
1. Gravitational Potential Energy
2. General Relativity

Pre-Class Summary:

The Gravitational Potential Energy $U_g = -G\frac{Mm}{r}$.

Einstein's Theory of General Relativity suggests that gravity is the bending of space caused by mass. Evidence for this theory includes the bending for light by masses such as that seen in gravitational lensing.

Gravitational Potential Energy Revisited



1. Write the definition of potential energy using dr in place of ds.

2. Carefully, do the dot product between the force and the displacement.

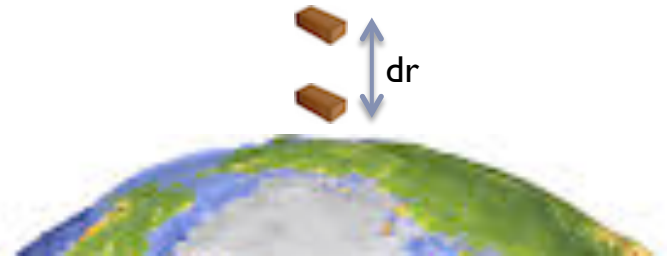
3. Use the Law of Universal Gravitation for the force.

4. Do the integration from r_i to r_f to get the change in potential energy.

5. Define the potential energy at infinity to be zero to get the expression for the gravitational potential energy.

Example 1: If we send people to Mars, they will need to have enough energy to have their return ship escape Mars' gravity. Find the minimum velocity necessary to leave Mars.

Where's mgh?



1. Write the expression for the gravitational potential energy for a brick of mass m near the surface of Earth.

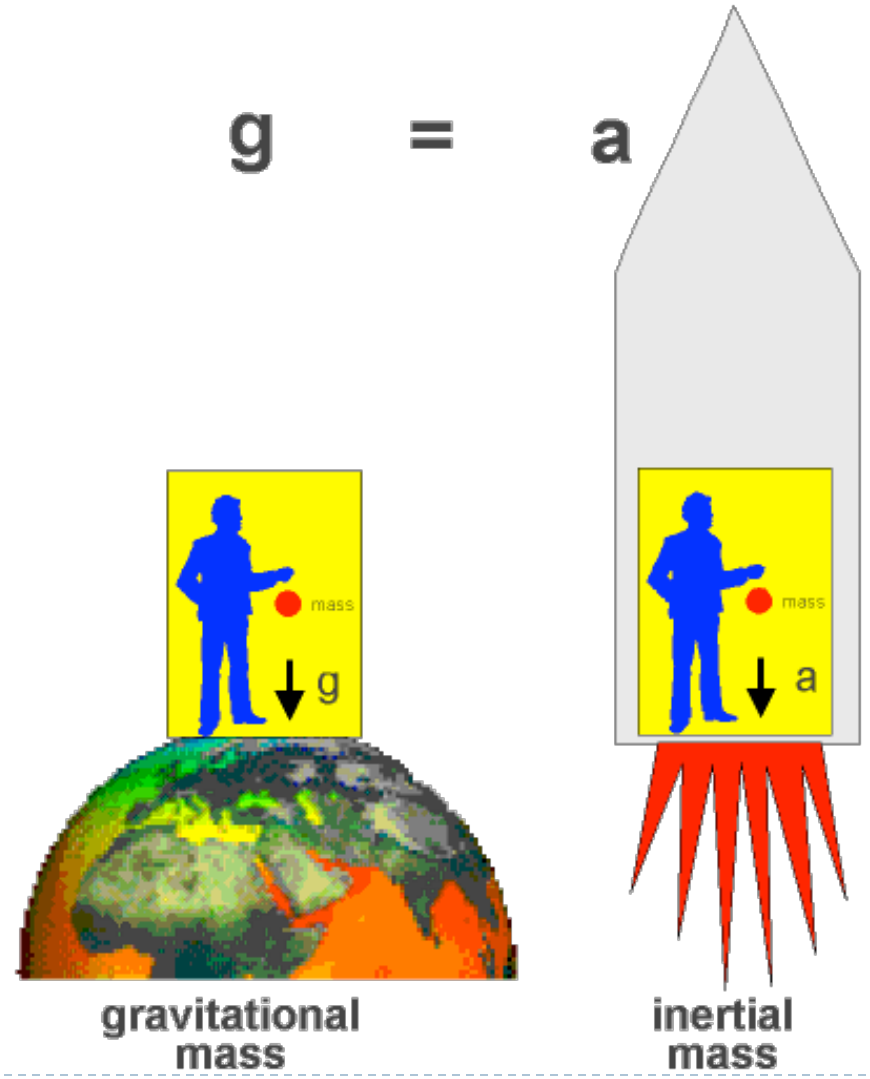
2. Take the derivative of the potential energy as a function of r to get the change in potential energy per change in r.

3. Notice the derivative is equal to the force on the brick so you can replace it with mg.

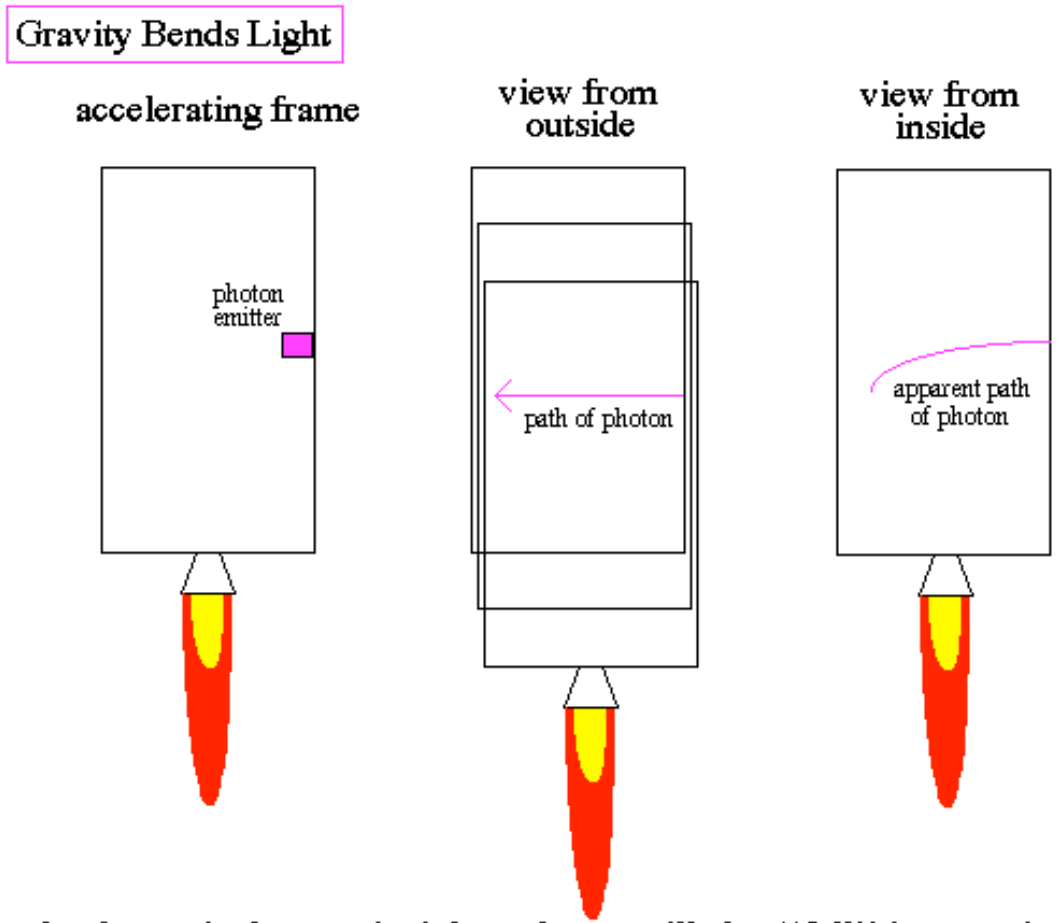
4. Change the d's to Δ's noting that $\Delta r = h$. Solve for ΔU.

Example 2: Find the minimum energy required to get 1000kg satellite into geosynchronous orbit.

Principle of Equivalence

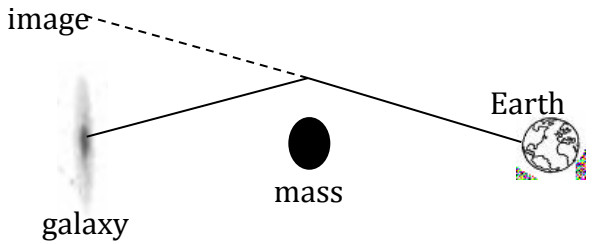


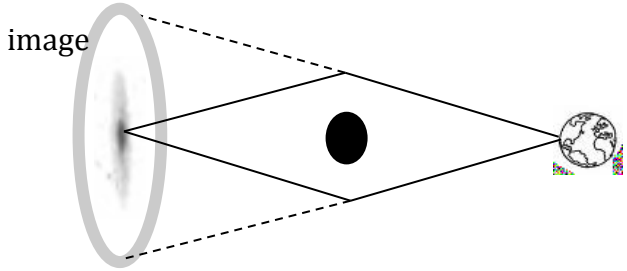
Light Bent by Gravitation



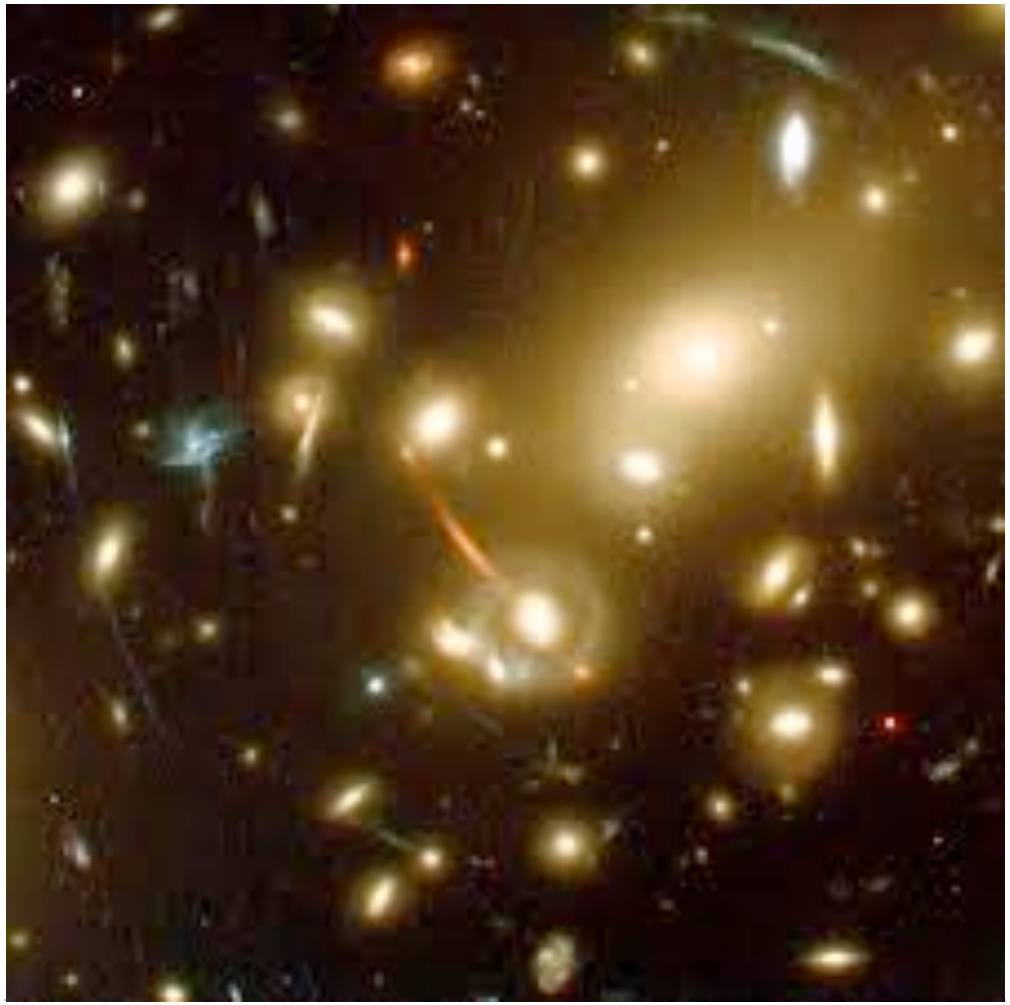
by the equivalence principle, a photon will also ''fall'' in a gravitational field

Gravitational Lensing





Gravitational Lensing Demonstration



Example 3: A horizontal laser beam travels 10.0m across a laboratory room. Find the distance it falls due to gravity.

Lecture 39 - Summary

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