1. (40 pts) Sir Isaac Newton published the law of gravitation in 1967.

$$F_g = \frac{Gm_1m_2}{r^2},$$

where F_g is the magnitude of the gravitational force on either particle, m_1 and m_2 are their masses, r is the distance between them, and G is a fundamental physical constant called the gravitational constant. Answer the following questions.
(a) (20 pts) Propose a method to determine the mass of the Earth.
(b) (20 pts) Give the potential error sources of your method.

2. (30 pts) Give a situation, phenomena, or reported experimental results that reveal the need of quantum theories.

3. (30 pts) Collectively, Maxwell's equations consist of the following four equations:

Gauss' law for electricity $\oint \vec{E}\cdot d\vec{A} = q_{enc}/\varepsilon_0$, or $\nabla\cdot\vec{E} = \rho$,

Gauss' law for magnetism $\oint \vec{B}\cdot d\vec{A} = 0$, or $\nabla\cdot\vec{B} = 0$,

Faraday's law $\oint \vec{E}\cdot d\vec{s} = -d\Phi_B/dt$, or $\nabla\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}$, and

Ampere-Maxwell law $\oint \vec{B}\cdot d\vec{s} = \mu_0(\varepsilon_0 d\Phi_E/dt + i_{inc})$, or $\nabla\times\vec{B} = \mu_0\vec{J} + \mu_0\varepsilon_0\frac{\partial\vec{E}}{\partial t}$.

Maxwell's equations, while supplemented by the Lorentz force equation $\vec{F} = q(\vec{E} + \vec{v}\times\vec{B})$ and the conservation of charge, describe a lot of the electromagnetic phenomena we encounter.

Let c be the speed of electromagnetic waves in vacuum. Then,

$$c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}.$$

Derive the above formula.