編號： 294　系所：製造工程研究所丙組　　科目：物理

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Physics (2007)

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 value of G.

(b) (20 pts) Give the potential error sources of your method.

2. (30 pts) Let $U_0 > 0$, and let $U(x)$ be a potential function, where

$$U(x) = 0 \quad \text{for} \quad 0 \le x \le L, \text{ and}$$
$$U(x) = U_0 \quad \text{for} \quad x < 0 \quad \text{or} \quad x > L.$$

This function is often called a square-well potential. A particle of mass *m* is trapped in the well. Let *E* be the total energy of the particle, where $E < U_0$. Then, the particle is bound. Find the bound-state solutions of the Schrödinger equation.

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

Gauss' law for electricity	$\oint \vec{E} \cdot d\vec{A} = q_{enc} / \varepsilon_0$,
Gauss' law for magnetism	$\oint \vec{B} \cdot d\vec{A} = 0$,
Faraday's law	$\oint \vec{E} \cdot d\vec{s} = -d\Phi_B / dt$, and
Ampere-Maxwell law	$\oint \vec{B} \cdot d\vec{s} = \mu_0(\varepsilon_0 d\Phi_E / dt + i_{inc})$.

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. Answer the following questions.

(a) (15 pts) A coil of wire containing 500 circular loops with radius 4.00 cm is placed between the poles of a large electromagnet, where the magnetic field is uniform and at an angle of 60° with the plane of the coil. The field decreases at a rate of 0.200 T/s. What are the magnitude and direction of the induced emf?
Give your answer clearly. Draw a graph if it is needed to clarify your answer.

(b) (15 pts) Let c be the speed of electromagnetic waves in vacuum. Then,

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

Give the assumptions about electromagnetic waves that are needed to derive the above speed formula of electromagnetic waves in vacuum from Maxwell's equations.