1. Please determine each of the following statement is correct or incorrect. Explain your determination.
(a) (4%) To describe the motion a point particle in an inertia frame, we simply need Newton's 2nd law ($\vec{F} = m\vec{a}$) with appropriate initial conditions. However, to describe the motion of a rigid body, we need $\vec{\tau} = I\vec{\alpha}$ in addition to $\vec{F} = m\vec{a}$. (Here $\vec{F}$ is the force applied to the point particle or the rigid body, m the mass of the point particle or the rigid body, $\vec{a}$ the acceleration of the point particle or the center of mass of the rigid body, $\vec{\tau}$ the torque applied to the rigid body, and $\vec{\alpha}$ the angular acceleration of the rigid body with respect to the rigid body's center of mass.)
(b) (4%) Gravitational force, electrostatic electric force, electrostatic magnetic force and resistance force are all conservative forces.
(c) (2%) Release a solid sphere and a hollow sphere of the same radius and mass from the same point on an incline and let them roll without slipping. The hollow sphere will reach the bottom first.
(d) (2%) A solid sphere and a hollow sphere of the same radius and mass undergo free fall from the same altitude at the same time. The solid sphere will reach the floor first.
(e) (4%) Centripetal force and centrifugal force are an action-reaction pair.
(f) (4%) Magnitude of the electron energy in a hydrogen atom is larger than the kinetic energy of a hydrogen molecule at room temperature.

2. $\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$ denotes a one dimensional wave equation. In this equation y denotes the disturbance, x the position, v the wave speed and t the time.
(a) (3%) Please prove that $y = f(x \pm vt)$ satisfies the above wave equation. Here f is an arbitrary function.
(b) (4%) Please explain that $f(x \pm vt)$ express a traveling wave.
(c) (3%) What disturbances do y's denote for a sound wave and an electromagnetic wave?

3. When both the sound source and the observer stand still on the earth, the observer hears a sound with a frequency of f_0, a wavelength of λ_0 and thus a sound speed of $v = \lambda_0 f_0$.
(a) (4%) When the observer moves, with a speed of v_0, towards the sound source which keeps still on the earth, does the sounded frequency become $f' = \frac{v + v_0}{v} f_0$, $f' = \frac{v}{v - v_0} f_0$ or what else ? What does the wavelength become ?
(b) (4%) On the contrary, when the light source moves, with a speed of v_0, towards the observer who keeps still on the earth, does the sound frequency turn

out to be $f' = \frac{v + v_0}{v} f_0$, $f' = \frac{v}{v - v_0} f_0$ or what else ? How about the wavelength?

(c) (2%) In (b) and (c) above , does the observer hear equal frequency?

4. (10%) If we replace the sound source in the problem above by a light source but maintain all the else processes unchanged, will the observer see the same light frequency when he moves towards the light source or the light source moves towards him with the same speed.

5. (10%) Show that the efficiency of a heat engine operating in a Carnot cycle using an ideal gas is given by the equation of $e_c = 1 - T_c/T_h$, where T_c and T_h represent the lowest and the highest temperature of the reservoir, respectively.

6. A solid, insulating sphere of radius **a** has a uniform charge density ρ and a total charge ***Q***. Concentric with this sphere is an uncharged, conducting hollow sphere whose inner and outer radii are **b** and **c**, as shown in Fig. **(1)** .
(a) (10%) Find the magnitude of the electric field in the regions **r<a**, **a<r<b**, **b<r<c**, **r>c**.
(b) (5%) Determine the induced charge per unit area on the inner and outer surfaces of the hollow sphere.

7. (10%) A resistor **R**, an inductor **L**, and a capacitor **C** are connected in series to a **ΔV** (rms) source having variable frequency. What is the energy delivered to the circuit during one period if the operating frequency is **twice** the resonance frequency?

8. (a) (8%) Please explain the physical meaning of the Maxwell's equations.
(b) (7%) Show me how to use one of them to derive the equations of electric and magnetic fields of plane electromagnetic waves. **(7%)**

Fig. 1