1. A wheel rotates from rest about a fixed axis through its center of mass such that $\theta = bt^3$, where b is a positive constant with units rad/s . a) Show that the work done by the net torque on the wheel when it has turned through an angle θ is $(9/2)I_{cm}b^{2/3}\theta^{4/3}$. b) Calculate the angular speed of the wheel when it has turned through an angle θ. c) Use the result of part (b) to calculate the kinetic energy of the wheel when it has turned through an angle θ. Is the work-energy theorem obeyed? Explain. (16%)

2. A parallel-plate capacitor has the volume between its plates filled with plastic with dielectric constant K. The magnitude of the charge on each plate is Q. Each plate has area A, and the distance between the plates is d. a) Use Gauss's law to calculate the magnitude of the electric field in the dielectric, b) Use the electric field determined in part (a) to calculate the potential difference between the two plates, c) Use the result of part (b) to determine the capacitance of the capacitor. (16%)

3. A long, straight copper wire with a circular cross-section area of 2.1 mm^2 carries a current of 16 A. The resistivity of the material is $2.0 \times 10^{-8}\,\Omega m$. a) What is the uniform electric field in the material? b) If the current is changing at the rate of 4000 A/s, at what rate is the electric field in the material changing? c) What is the displacement-current density in the material in part (b)? (Hint: Since K for copper is very close to 1, use $\varepsilon = \varepsilon_0$). d) If the current is changing as in part (b), what is the magnitude of the magnetic field 6.0 cm from the center of the wire? (16%)

4. a) A forward-bias voltage of 15.0 mV produces a positive current of 9.25 mA through a p-n junction at 300 K. What does the positive current become if the forward-bias voltage is reduced to 10.0 mV? b) For reverse-bias voltages of -15.0 mV and -10.0 mV, what is the reverse-bias negative current? ($e = 1.602 \times 10^{-19}$ C, $k = 8.617 \times 10^{-5}$ eV/K) (16%)

5. a) For the Otto cycle shown in Fig. 1, calculate the entropy changes of the gas in each of the constant-volume processes $b \rightarrow c$ and $d \rightarrow a$ in terms of the temperatures T_a, T_b, T_c, and T_d and the number of moles n and the heat capacity C_v of the gas. b) What is the total entropy change in the engine during one cycle? (Hint: Use the relation between T_a and T_b, and between T_d and T_c). (16%)

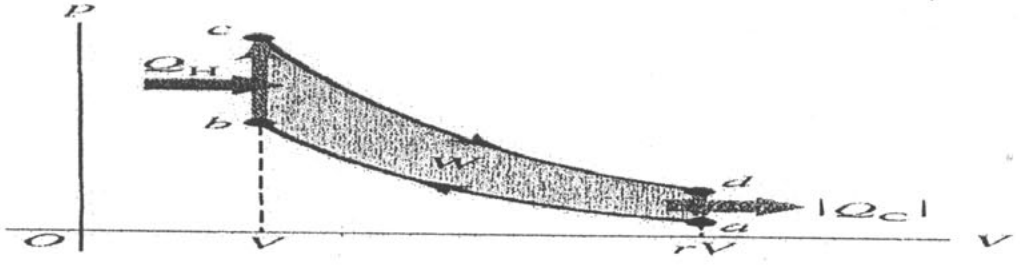

Fig. 1

6. Explain the following terms in words.
   a) dielectric strength, dielectric breakdown.(5%)
   b) hole current in semiconductor.(5%)
   c) the fundamental forces of nature.(10%)