

所別：天文研究所碩士班 科目：普通物理

(1) (20 points)

- (a) (5 points) A mass  $m$  is attached to a spring with spring constant  $k$ . Write down and solve the equation of motion.
- (b) (10 points) Two identical system as in (a) are coupled through friction between the two masses. Assume that the friction is proportional to the relative velocity between the two masses. Write down and solve the equations of motion. Describe the modes of motion.
- (c) (5 points) Discuss what will happen to the modes if (i) the two masses are different, and (ii) the two force constants are different.

(2) (20 points)

A sphere of mass  $M$  has a spatially uniform but time dependent density  $\rho(t)$ . The time dependence of the radius  $a$  and  $\rho$  can be found by considering the motion of a particle on the surface of the sphere.

- (a) (5 points) Write down the equation of motion of the particle and derive

$$\frac{1}{2}m\mathbf{v} \cdot \mathbf{v} - \frac{4\pi a^2 Gm\rho}{3} = E.$$

Is  $E$  a constant when  $\rho$  depends on time?

- (b) (15 points) Suppose the particle moves in radial direction only, i.e., it represents the motion of the surface of the mass sphere. Find  $\rho(t)$  and  $a(t)$  if  $E = 0$ .

(3) (20 points)

- (a) (5 points) Describe the first and second law of thermodynamics.
- (b) (5 points) What is an ideal gas? What assumptions are needed?
- (c) (10 points) Using the first law of thermodynamics (and expressing internal energy, entropy, etc. as functions of temperature and volume), show that the internal energy of a fixed mole of ideal gas depends on temperature only.

(4) (20 points)

- (a) (10 points) Write down the Maxwell's equations in SI units, describe the physics of each equation. Derive the charge conservation equation from the Maxwell's equations.
- (b) (10 points) A circular parallel plate capacitor, of radius  $a$ , is discharging at a rate  $Q = Q_0 \exp(-t/\tau)$ . Assuming the charges are uniformly distributed on the plate and neglecting the edge effect, find the magnetic field distribution (magnitude and direction) inside and outside the capacitor.

(5) (20 points)

- (a) (5 points) Describe three wave phenomena of light that cannot be explained in terms of particles but can be explained in terms of waves.
- (b) (15 points) A thin film of refractive index  $n = 6/5$  is suspended in vacuum. A visible light source has wavelengths from 360 nm to 720 nm is incident normally on the thin film. It is observed that 400 nm and 600 nm are missing in the reflected light. Find the minimum possible thickness of the thin film. What is(are) the most strongly reflected visible wavelength(s)? What is(are) the most strongly transmitted visible wavelength(s)?