選擇題 (30 分)

1. (6 %) The compression ratio of a diesel engine is 5 to 1; this means that the air in the cylinder is compressed to 1/5 of its initial value. If the process is adiabatic with the initial pressure 1 atm and the initial temperature 27°C, find the final pressure after the compression by treating air as an ideal gas with $\gamma = C_p/C_v = 2$ (ratio of molar heat capacities at constant pressure C_p and constant volume C_v).
   (a) 0.2 atm   (b) 1 atm   (c) 5 atm   (d) 25 atm   (e) 50 atm.

2. (6 %) An object with mass m initially at rest is acted on by a force $F = k_1 i + k_2 t^3 j$, where k_1, k_2 are constants, and i, j are the unit vectors in x and y directions, respectively. What is the velocity $v(t)$ of the object as a function of time t.
   (a) $(k_1 t^2/m)i + (k_2 t^3/4m)j$ (b) $(k_1 t/m)i + (k_2 t^3/4m)j$ (c) $(k_1 t/m)i + (k_2 t^4/4m)j$ (d) $(k_1 t^3/m)i + (k_2 t/4m)j$ (e) $(k_1 t^2/m)i + (k_2 t^2/4m)j$.

3. (6 points) Find the period of a simple pendulum 2.4 m long at a location where the gravitational acceleration $g = 9.6$ m/s^2.   (a) $\pi/2$ (b) π (c) 2π (d) 4π (e) 16π.

4. (6 %) A turbine fan in a jet engine has a moment of inertia of 2.5 kg·m^2 about its axis of rotation. As the turbine is starting up, its angular velocity as a function of time is $\omega_z = (40$ rad/s$^3)t^2$. What is the torque acting on the fan at time $t = 3.0$ s?
   (a) 600 N·m   (b) 650 N·m   (c) 800 N·m   (d) 1200 N·m   (e) 1300 N·m.

5. (6 %) Suppose you want to place a weather satellite into a circular orbit at a height d above the earth's surface. Assume the earth's radius is R_E and its mass is m_E. The gravitational constant is G. What the period must it have?   (a) $2\pi(2R_E+d)^{3/2}/(2Gm_E)^{1/2}$ (b) $2\pi(R_E+d)^{3/2}/(Gm_E)^{1/2}$ (c) $\pi(R_E+d)^{3/2}/(Gm_E)^{1/2}$ (d) $3\pi(R_E+d)^{3/2}/(2Gm_E)^{1/2}$ (e) $4\pi(R_E+d)^{3/2}/(Gm_E)^{1/2}$.
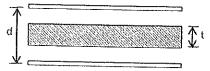
計算與簡答題 (70 分)

1. (10 %) A geologist working in the field drinks her morning coffee out of an aluminum cup. The cup has a mass of 0.120 kg and is initially at 20.0°C when she pours in 0.300 kg of coffee initially at 70.0°C. What is the final temperature after the coffee and the cup attain thermal equilibrium? The specific heats for water and aluminum are 4190 J/kg·K and 910 J/kg·K, respectively. (Assume the coffee has the same specific heat as water and that there is no heat exchange with the surroundings.)

2. (10 %) A block with mass M attached to a horizontal spring with force constant k is moving with simple harmonic motion having amplitude A_1. At the instant when the block passes through its equilibrium position, a lump of putty with mass m is dropped vertically onto the block from a very small height and sticks to it. Find the new amplitude and period.

3. A dielectric slab of thickness t and dielectric constant κ is inserted into a parallel plate capacitor with surface charge density σ and plates of area A, separated by distance d, shown as below. Assume that the battery is disconnected before the slab is inserted. (a) What is the electric field in the dielectric? (3%) (b) What is the potential difference between the plates? (5%) (c) What is the capacitance of the parallel plate capacitor? (7%)

4. (a) Write down Ampere's law in differential form. (2%) (b) Explain why Ampere's law is not valid in non-steady current case. (3%) (c) Please describe how did Maxwell modify Ampere's law and show the Maxwell's modification of Ampere's law is valid for non-steady current case. (10%)

5. Would a color filter that allows just one color to pass through it improve the resolution of a microscope? (2%) If so, for what reason? (2%) Which color would produce the best resolution? (3%)

6. Why is it difficult to produce an incandescent bulb with a visible spectrum similar to sunlight? (3%)

7. Two point sources S_1 and S_2 are in phase and emitting light with the same wavelength (λ). They are a distance d apart along a line perpendicular to a screen as in figure shown in below. (a) What is seen on the screen? (3%) (b) Assuming $d \ll L$, find the position y_m, of the mth maximum relative to the center O. (7%)