(一) Heat　(共25分)

1. **Heat flow** (熱流) is the rate of heat energy transfer through a given surface, per unit surface and per unit second. What is the relationship between heat flow, temperature, and thermal conductivity? (10分)

2. Along a metal bar, the temperature is $T(x)=x^2$ at distance x in cm along the bar, and that the heat flow is *100 J/s* at x= 200 cm, what is the constant of proportionality. (15分)

(二)　Rotation (共 25 分)

1. What is parallel axis theorem? (10 分)

2. 若地球對自轉軸的轉動慣量為kMR^2，其中M為地球質量、R為地球半徑。由於潮汐對海岸的摩擦作用，地球自轉的速度逐漸減小，每**1000**萬年周期增加**400**秒，求潮汐對地球的平均力矩多大？**(8分)** 地球動能的減小相當於摩擦消耗多大的功率？(7分)

(三)　Simple harmonic motion and friction (共 25 分)

A block of mass **m** rests on an incline which makes an angle θ with the horizontal plane (see the right figure). There is friction between the block and the surface. The static friction coefficient μ_s is larger than the kinetic friction coefficient, μ_k. The block is attached to a "massless" spring of spring constant k. In the absence of any forces on the spring, its (relaxed) length would be l.
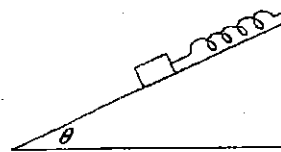
(1)　We pull on the block and extend the spring till its length is $l+x$. What is the maximum extension, x_{max}, of the spring for which the block will remain stationary when released? (5 分)

(2)　In this position, show a free body diagram for the block. Indicated all forces that act on the block and give their magnitude. (5 分)

In the following three questions, use the symbol x_{max}.

(3)　In this position, the block is then gently touched at time $t=0$. It starts moving. For what value of x will the block reach its maximum speed? (5 分)

(4)　As the block moves, the spring will get shorter. At some point in time, t_1, the extension is x. How much work was done by (i) gravity, (ii) the spring force, and (iii) by the friction between $t=0$ and t_1. (5 分)

(5)　As the block moves up-hill, the spring gets shorter. What is a necessary requirement for the spring to become at least as short as its relaxed length l ? (5 分)

(四) Magnetic field　(共25分)

(1) What is Biot-Savart law (10 分)

(2) Two wires, both of length L, are formed into a circle and a square, and each carries current i. Show that the square produces a greater magnetic field at its center than the circle produces at its center. (15 分)