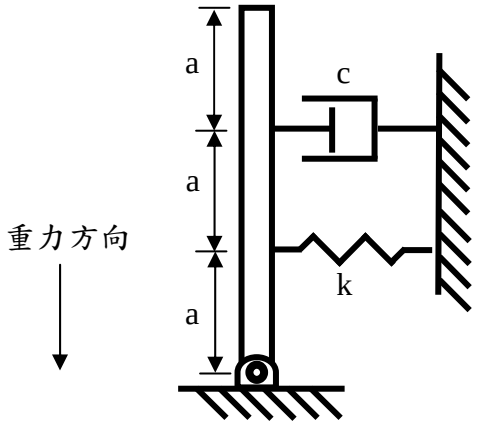
國立虎尾科技大學　機械與機電工程研究所

98 學年度第 2 學期　博士班資格考 【振動學】

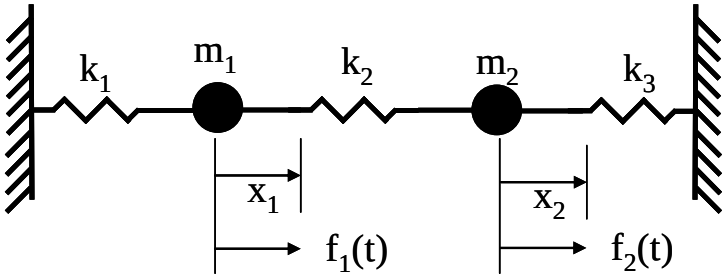
1. 舉例日常生活週遭與振動問題相關 4 個不同之案例，並根據**振動學理論詳細**說明振動問題可能導致影響。(20%)

2. **詳細**說明下列所代表之意義：
   (a) 運動方程式(Equation of motion)(5%)
   (b) 自由度(Degree of freedom)、離散系統(Discrete system)與連續系統(Continuous system)(5%)
   (c) 簡諧運動(Harmonic motion)(5%)
   (d) 共振現象(Resonance)(5%)
   (e) 解釋次阻尼系統(Under-damped system)、臨界阻尼系統(Critical-damped system)與過度阻尼系統(Over-damped system)，並比較三者之差異。(10%)

3. 如圖所示，一單位長度質量為 m 之細長桿件，已知圖中阻尼器之阻尼為 c，試求在微小擾動下(Hint: $\sin\theta \approx \theta$)仍可保持穩定系統之彈簧係數 k 必須符合之條件為何？(20%)



4. 如圖所示之質點彈簧系統，若質點質量 $m_1 = m_2 = 1$ ，彈簧彈性係數 $k_1 = k_3 = 4$ 且 $k_2 = \frac{5}{2}$ ，作用外力 $f_1(t) = 2[1 - H(t-3)]$ 且 $f_2(t) = 0$，其中 $H(t)$ 表示 Heaviside 函數或亦稱為 Unit step function，圖中質點 1 與質點 2 之平衡位置且亦為初始位置分別位於 $x_1 = 0$ 與 $x_2 = 0$ 之位置，質點 1 與質點 2 之初始速度皆為零，試求
   (a) 系統之運動方程式(10%)
   (b) 系統之位移響應(10%)



國立虎尾科技大學 102 學年度第一學期博士班資格考試題

所別：動力機械工程系機械與機電工程博士班　　第 1 頁　共 2 頁

科目：振動學

注意事項：
（1）本試題共有 5 題，每題 20 分，合計一百分。
（2）請依序作答於答案卷上並註明題號，若未註明選答題號及超過規定題數時，謹採計作答順序較前之題目計分。
（3）可 使用計算機

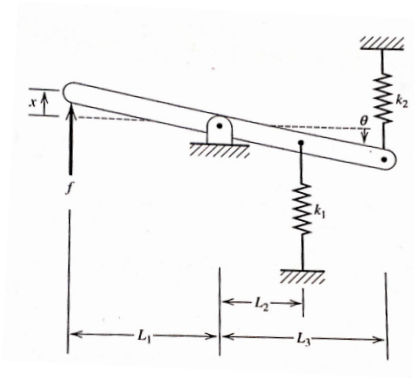
1. (a)What the definition of good and bad vibration? Give two examples for each vibration.
   (b)What are the three basic elements in a vibratory system.
2. In the spring arrangement shown in Fig.1, the displacement x is caused by the applied force f. Assuming the system is in static equilibrium and that the angle θ is small, determine the equivalent spring constant k_e for this arrangement, where $f=k_e x$.
3. Obtain the equation of motion in terms of x for the system shown in Fig.2. The equilibrium position is at x=0 when f=0.
4. Obtain the free response of the following model,

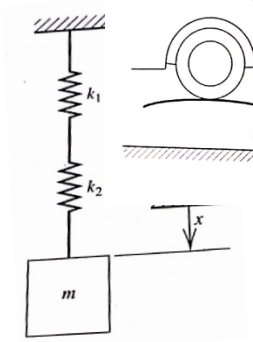
$$2\ddot{x} + 10\dot{x} + 8x = 0$$

   for the following three cases: (a) $x(0) = 2, \dot{x}(0) = 5$; (b) $x(0) = 2, \dot{x}(0) = -5$; (c) $x(0) = 2, \dot{x}(0) = 0$.
5. (a)Write the definition of free response and forced response vibration. (b) Figure 3 shows a quarter-car representation, where the stiffness k is the series combination of the tire and suspension stiffnesses. The equation of motion is given as

$$m\ddot{x} + c\dot{x} + kx = c\dot{y} + ky$$

   Suppose the road profile is given (in feet) by $y(t) = 0.03\sin(\omega t)$, where the amplitude of vibration of the road surface is 0.03 ft and the frequency ω. Suppose the period of the road surface is 20 ft. Compute the steady state motion amplitude and the force transmitted to the chassis for two cars traveling at speed of 50 mi/hr. The car has a mass of 900 kg. $k=2.9\times10^4$ N/m and c=5300 N﹫s/m.





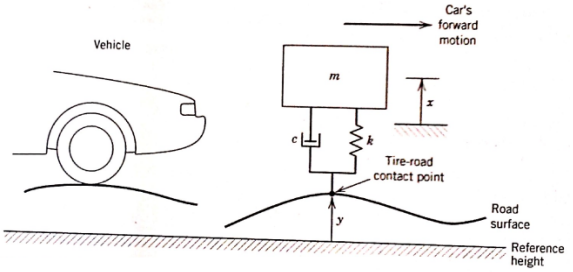


Figure 1 Figure 2 Figure 3

國立虎尾科技大學 102 學年度第二學期博士班資格考試題

所別：機械與機電工程研究所　　第 1 頁　共 1 頁

科目：振動學

注意事項：

（1）本試題共有 5 題，每題 20 分，合計一百分。 Closed book

（2）請依序作答於答案卷上並註明題號，若未註明選答題號及超過規定題數時，謹採計作答順序較前之題目計分。

（3）可使用計算機

1. (a)What the definitions of free and forced vibration? Give two examples for each kind vibration. (b)What are the three basic elements in a vibratory system? Give example for each other.
2. (a)What's the simple harmonic motion? Write it's relationship between displacement and acceleration. (b) write the motion function of a pendulum system as shown in Fig.1, and discuss what condition the system can be became a simple harmonic motion.
3. In the pulley system shown in Fig. 2, assume that the cable is massless and inextensible, and assume that the pulley masses are negligible. The force *f* is a known function of time. Derive the system's equation of motion in terms of the displacement x_1.
4. Figure 3 shows a motor mounted on a cantilever beam support. It's impossible to balance the motor perfectly, and the imbalance will result in a vertical force f that oscillates at the same frequency as the motor's rotational speed. Determine the expression for the natural frequency of the system.
5. Give the model, $\ddot{x} - (r+2)\dot{x} + (2r+5)x = 0$
   (a) Find the values of the parameter r for which the system is (i) stable, (ii) neutrally stable, (iii) unstable.
   (b) For the stable case, for what values of r is the system (i) underdamped, (ii) overdamped?

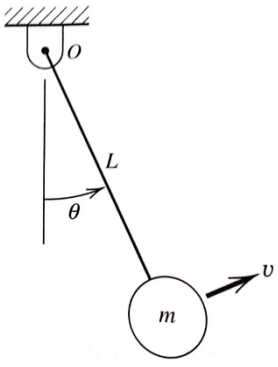


Figure 1

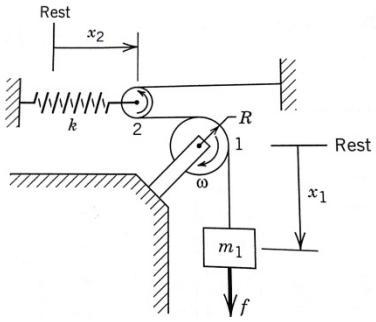


Figure 2

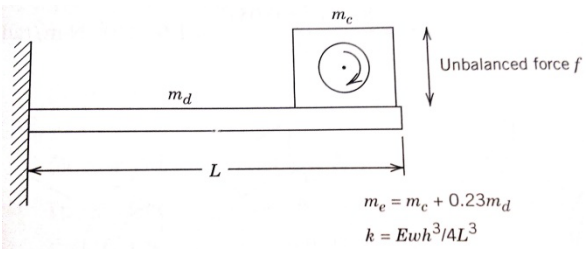


Figure 3

國立虎尾科技大學 105 學年度第二學期博士班資格考試題

所別：動力機械工程系機械與機電工程博士班　　第 1 頁　共 2 頁

科目：振動學，Mechanical Vibration

Notice :

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（3）可使用計算機。Calculator is available.

1. (a) Please write definitions of vibration and oscillation, respectively. And give an example for each case. (b) What's the natural frequency of a structure? How to find it? Resonance frequency, measured from scanning frequency method, is near to the natural frequency for a structure but they are different. Please draw a frequency-amplitude figure and explain why?

2. The model of the vibration isolator shown in Fig.1 is $0.5\dot{y}_1 + y_1 = 12 + 6\sin(t) + 3\cos(6t)$, Obtain the expression for the steady-state response.

3. In the pulley system shown in Fig.2, assume that the cable is massless and inextensible, and the pulley masses are ignored. The force *f* is a known function of time. Derive the system's equation of motion in terms of the displacement x_1.

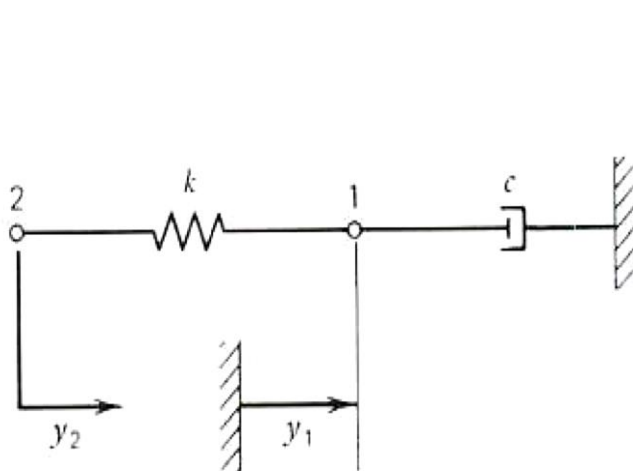

Fig.1

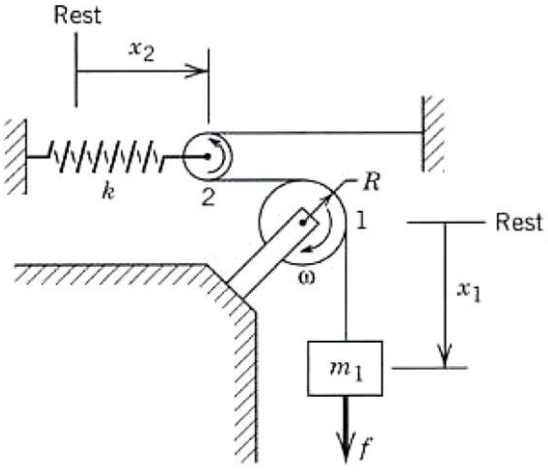

Fig.2

國立虎尾科技大學 105 學年度第二學期博士班資格考試題

4. Apply Rayleigh's method to determine the natural frequency of the cylinder shown in Fig.3. Neglect the mass of spring and the roller is pure rolling.

5. The 0.5 kg mass shown in Fig.4 is attached to the frame with a spring of stiffness k= 500 N/m. Neglect the spring weight and any damping. The frame oscillates vertically with amplitude of 4 mm at a frequency of 3 Hz. Compute the steady-state amplitude of motion of the mass.

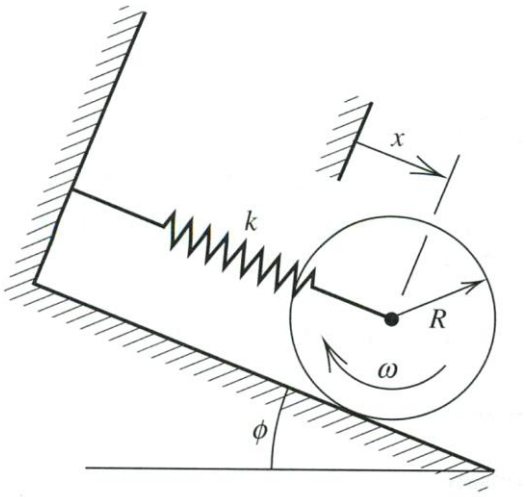

Fig.3

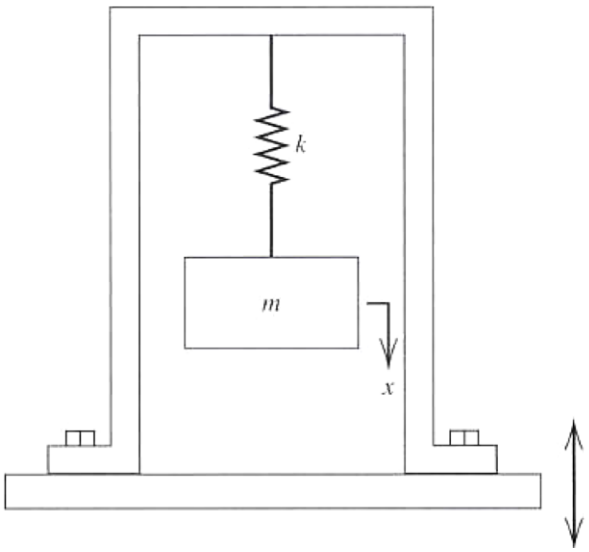

Fig.4

TABLE 4.1-2 Steady-State Sine Response of a Second-Order Model

Model: $m\ddot{x} + c\dot{x} + kx = F_o \sin \omega t$

$$\zeta = \frac{c}{2\sqrt{mk}} \qquad \omega_n = \sqrt{\frac{k}{m}} \qquad r = \frac{\omega}{\omega_n}$$

Steady-state response:

$$x_{ss}(t) = \frac{F_o}{k} \frac{1}{\sqrt{(1-r^2)^2 + (2\zeta r)^2}} \sin(\omega t + \phi)$$

$$\phi = -\tan^{-1} \frac{2\zeta r}{1-r^2}$$

Third quadrant if $1 - r^2 < 0$
Fourth quadrant if $1 - r^2 > 0$
$\phi = -90^\circ$ if $r^2 = 1$

參考書籍: **Mechanical Vibration, William J. Palm III, Wiley**

範圍:

1. Introduction to mechanical vibration
2. Models of one degree of freedom
3. Free response of single degree of freedom
4. Harmonic response of single degree of freedom
5. General force response

國立虎尾科技大學 106 學年度第一學期博士班資格考試題

所別：機械與機電工程研究所　　第 1 頁　共 2 頁

科目：振動學，Mechanical Vibration

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（3）可使用計算機。Calculator is available.

1. Write definitions of these vibration phenomena，(a) Forced vibration system；(b)Simple harmonic vibration；(c) Equivalent mass and inertia；(d) Beating and Resonance。

2. Vibration sources of a machine can be sorted as active and passive signals. (a) How to find the active signal in the frequency domain. How to measure the natural frequency of a structure. (b) A spindle testing time-frequency map is shown in the Fig.1. Write your opinions how to verify active signals of bearing and the passive signal of the structure

3. The static deflection of a cantilever beam is described by

$$x_y = \frac{P}{6EI_A} y^2(3L - y)$$

where P is the load applied at the end of the beam and x_y is the vertical deflection at a point a distance y from the support. Please use the method of kinetic energy equivalence to obtain the equivalent mass and write the motion function.

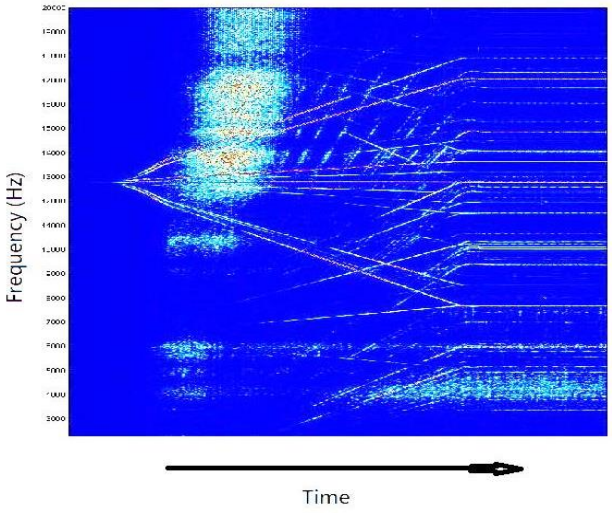

Figure 1

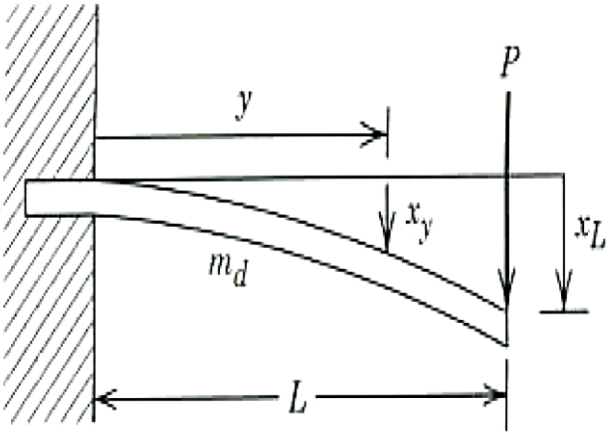

Figure 2

4. A box car of mass 18000 kg hits a shock absorber at the end of the track while moving at 1.3 m/s, as shown in the Fig.3. The stiffness of the absorber is k=73000 N/m and the damping is c=88000 $\mathrm{N \cdot s/m}$. Determine (a) the maximum spring compression and (b) the time for boxcar to stop.

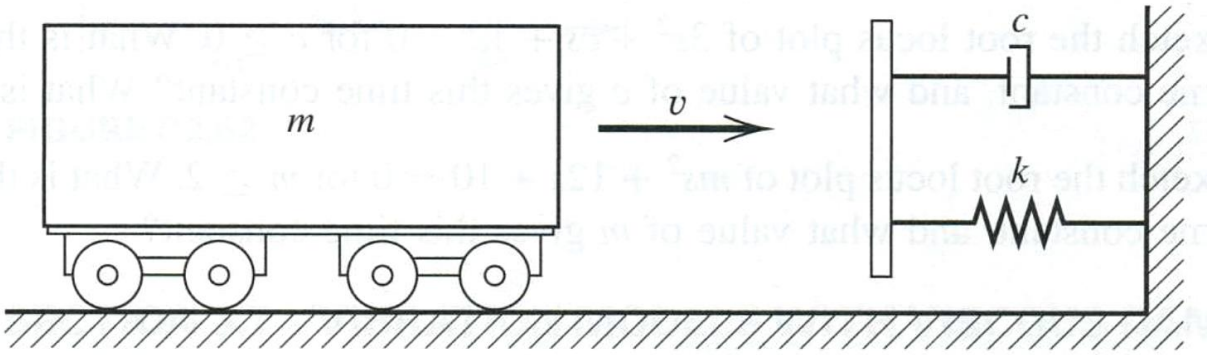

Figure 3

5. A sinusoidal force 500 sin (150t) N acts on a mass spring system. The mass is 11 kg and moves on a horizontal surface. The coefficient of dynamic friction between the mass and the surface is μ=0.3. The spring stiffness is k=17500 N/m.

   Calculate the amplitude, *X*, and phase angle, ϕ, of the steady-state displacement of the mass. And write the steady-state response. The equation of motion is

   $\mathrm{m}\ddot{x} + 2\zeta_e\omega_n\dot{x} + \omega_n^2 x = \frac{F}{m}sin(\omega t)$ ， where, $\zeta_e = \frac{c_e}{2\sqrt{mk}}$ ； $c_e = \frac{4\mu N}{\pi\omega X}$ ； $x = Xsin(\omega t + \phi)$(steady-state displacement)

國立虎尾科技大學 110 學年度第 1 學期博士班資格考試題

系別：動力機械工程系機械與機電工程博士班

科目：振動學 Mechanical Vibration

注意事項：

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（3）可以使用計算機 close book and can use calculator

1. (20%)Consider a system of two springs, with stiffnesses K_1 and K_2 arranged in parallel as shown in Fig. 1. The rigid bar to which the two springs are connected remains horizontal when the force *F* is zero. Determine the equivalent spring constant of the system (K_e) that relates the force applied (*F*) to the resulting displacement (*x*) as

$$F = K_e x$$

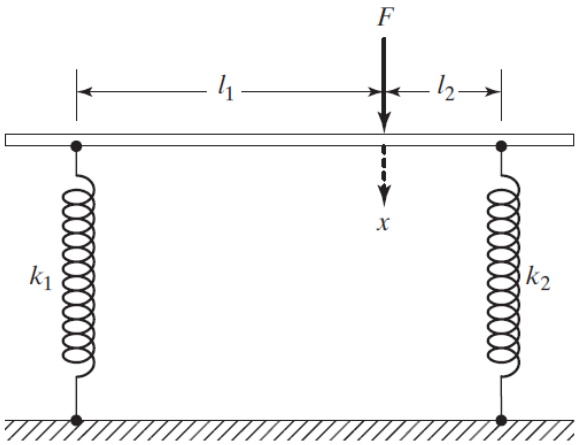

Fig.1: Parallel springs subjected to load.

2. Two nonlinear springs, S_1 and S_2 are connected in two different ways as indicated in Fig.2. The force, F_i in spring S_i related to its deflection (x_i) as

$$F_i = a_i x_i + b_i x_i^3,\ i = 1, 2$$

where a_i and b_i are constants. If an equivalent linear spring constant K_{eq}, is defined by $W = K_{eq} x$, where x is the total deflection of the system, find an expression for K_{eq} in each case. (20%)

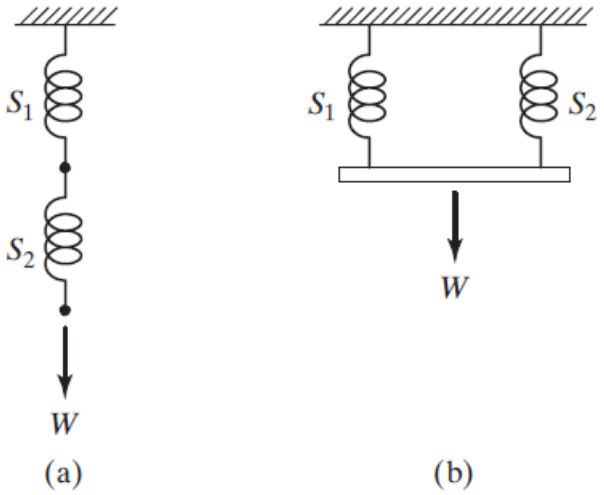

Fig.2:

3. In Fig. 3, a periodic force $F(t) = F_0 \cos \omega t$ is applied at a point on the spring that is located at a distance of 25 percent of its length from the fixed support. (1) drawing a free-body-diagram of the system (2) Assuming that $C = 0$ find the steady-state response of the mass *m.* (3) If $C \neq 0$, how to solve this system? (30%)

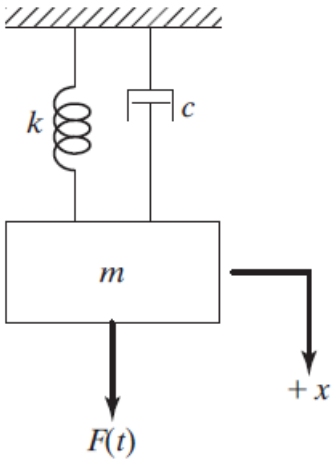

Fig.3

4. A helical spring of stiffness k is cut into two halves and a mass m is connected to the two halves as shown in Fig. 4(a). The natural time period of this system is found to be 0.5 s. If an identical spring is cut so that one part is one-fourth and the other part three-fourths of the original length, and the mass m is connected to the two parts as shown in Fig. 4(b), what would be the natural period of the system?(20%)

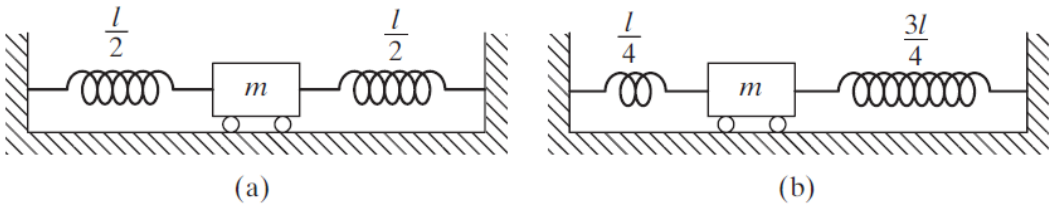

Fig.4

5. Find the natural frequency of the pulley system shown in Fig.5 by neglecting the friction and the masses of the pulleys. Use Rayleigh s method to solve this problem. Also, please draw a free-body-diagram of each spring and pully.(10%)

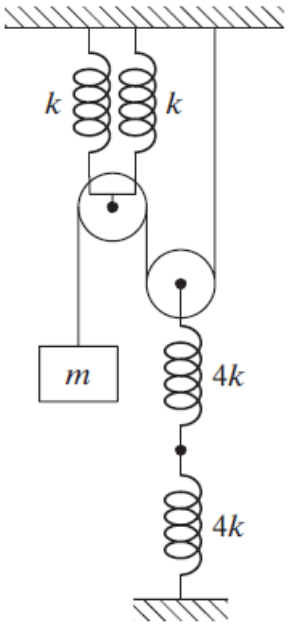

Fig.5

國立虎尾科技大學 111 學年度第 2 學期博士班資格考試題

系別：動力機械工程系機械與機電工程博士班

科目：機械振動學 (Mechanical Vibrations)

注意事項：
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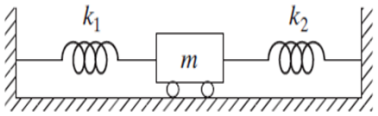
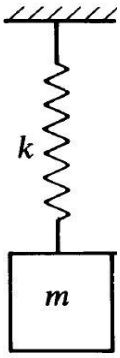
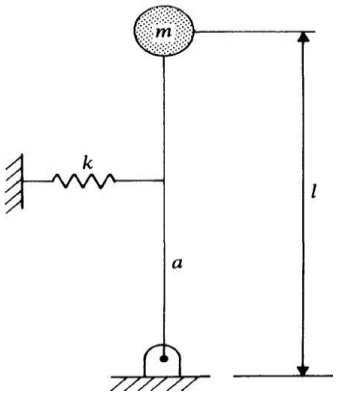
（3）可使用計算機(Engineering calculator is allowable)，Close book examination。

1.	**Derive the equation of motion of the system shown in the right figure, using the following methods:** **(a) Newton's second law of motion,** **(b) D'Alembert's principle,** **(c) Principle of virtual work,** **(d) Principle of conservation of energy.**	
2.	**A single degree of freedom system consists of a mass *m* which is suspended by a linear spring of stiffness *k*. The static equilibrium deflection of the spring was found to be 0.02 m. (a) Determine the system natural frequency. (b) Also determine the response of the system as a function of time if the initial displacement is 0.03m and the initial velocity is zero. (c) What is the total energy of the system if the mass m is equal to 5 kg?**	
3.	**The system shown in following figure consists of a mass *m* and a massless rod of length *l*. The system is supported by a spring which has a stiffness coefficient *k*.** **(a) Obtain the differential equation of motion.** **(b) Discuss the stability of the system.** **(c) Determine the stiffness coefficient *k* at which the system becomes unstable.**	
4.	**A spring-mass undamped single degree of freedom system is subjected to a harmonic forcing function which has an amplitude of 40 N and frequency 30 rad/s. The mass of the system is 2 kg and the spring coefficient is 1000 N/m. (a) Find the amplitude of the forced vibration. (b) Find the complete solution if the initial conditions are x_0 = 0.01 m, $\dot{x}_0$ = 2 m/s.**