

姓名 Name	王培博
学号 Student ID	0216282011
专业班级 Class	54班 9:10
学院 School	国教

Test Paper of Wuhan University of Technology (A)

2018-2019 Academic Year 1st Semester, Course: _____,

Closed-book Exam

Time: 120mins, Class hours: _____ Credits: _____ Total Points: 100, Percent in final evaluation

result: _____ % Date: _____

No.	一 I	二 II	三 III	四 IV	五 V	六 VI	七 VII	八 VIII	九 IX	十 X	合计 Total	Teacher
Full score											100	
Score	10	25	18	30	15						98	

得分 Score	10
-------------	----

I. Single-choice questions (2 points * 5=10 points)

1. (A) The basic characteristics of elastic elements are
- A. the elements that represent the relationship between force and displacement
 - B. the elements that represent the relationship between force and speed
 - C. the elements that represent the relationship between force and acceleration
 - D. the elements that represent the relationship between displacement and speed

2. (A) For the forced vibration under the simple harmonic excitation of the single-degree-of-freedom system, the magnitude of the response amplitude in the low-frequency zone, resonance zone and high-frequency zone mainly depends the system's

- A. spring stiffness, damping and inertia
- B. damping, spring stiffness and inertia
- C. inertia, spring stiffness and damping
- D. inertia, damping and spring stiffness

3. (B) The function that best reflects the correlation of random variables at different times in different random processes is

- A. autocorrelation function
- B. cross-correlation function
- C. auto-spectrum
- D. frequency response function

4. (C) There are mainly three kinds of vibration problems. Besides vibration analysis and prediction of vibration environment, what is the other vibration problem?

- A. vibration prediction
- B. vibration modeling
- C. system identification
- D. modal analysis

5. (A) The function that cannot reflect the inherent characteristics of the system is

- A. autocorrelation function
- B. impulse response function
- C. frequency response function
- D. natural frequency

得分 Score	25
-------------	----

II. Explanation of phases (5 points * 5=25 points)

6. Sample function

随机过程无法用确定的函数来表示, 每一个试验曲线都称为样本函数

7. Multi-degree-of-freedom vibration system

由多个独立坐标确定位置的系统

8. Power spectrum

在频域上表现随机振动函数过程的特征。

9. Spectral analysis

分析不同频率谐波的振幅比

10. Principle of dynamic vibration absorber

利用辅助质量的动力作用,使弹性元件作用于主振件上的力与强迫激振力正好大小相等方向相反。

得分
Score

18

III. Short-answer questions (10 points * 2 = 20 points)

11. Give examples to illustrate the similarities and differences between active vibration isolation and passive vibration isolation.

主动隔振: 振源本身为振源,需将其与地基隔离开减少对外界影响。比如发电机发电时会产生较大振动。

被动隔振: 振源为支座(运动)引起,同样需要防止这种振动,称为被动隔振,比如汽车上的发动机。

异: 振源不同

同: 都需将振源与其它元件隔开,减小振动影响

12. What are the concepts of impulse response function and frequency response function and their relationship?

脉冲响应函数和频率响应函数分别从时域和频域描述了系统的动态特性。

$$\text{关系: } H(\omega) = \frac{Y(\omega)}{X(\omega)}$$

得分
Score

30

IV. Calculation (10 points * 3 questions = 30 points)

13. The probability density function of random variable X is $p(x) = ae^{-b|x|}$, of which a and b are constants. Find the relationship between a and b , and when $a = 1$, determine the distribution function $F(x)$.

Solution:

$$\int_{-\infty}^{+\infty} p(x) dx = \int_{-\infty}^0 ae^{bx} dx + \int_0^{+\infty} ae^{-bx} dx = \frac{2a}{b} = 1$$

$$\text{所以 } 2a = b$$

$$\text{当 } a = 1 \text{ 时 } b = 2 \quad p(x) = e^{-2|x|}$$

$x < 0$ 时

$$F(x) = \int_{-\infty}^x e^{2x} dx = \frac{e^{2x}}{2}$$

$x \geq 0$ 时

$$F(x) = \int_{-\infty}^0 e^{2x} dx + \int_0^x e^{-2x} dx = 1 - \frac{1}{2}e^{-2x}$$

$$F(x) = \begin{cases} \frac{e^{2x}}{2}, & x < 0 \\ 1 - \frac{e^{-2x}}{2}, & x \geq 0 \end{cases}$$

14. It is already known that $R(x) = 25e^{-4|x|} \cos \omega \tau + 16$, work out $\mu(x)$, σ_x^2 , $S_x(\omega)$.

Solution: $\mu(x) = \lim_{T \rightarrow \infty} R(x) = 16$

$\sigma_x^2 = \lim_{T \rightarrow \infty} R(0) = 25 + 16 = 41$

$S_x(\omega) = E[R_x(\omega)] = \int_{-\infty}^{\infty} R_x(\tau) e^{-i\omega\tau} d\tau$

$\therefore \cos \omega \tau = \frac{1}{2} (e^{i\omega\tau} + e^{-i\omega\tau})$

$S_x(\omega) = \frac{25}{4} \frac{8 + \omega^2}{4 + \omega^2} + 32\pi \delta(\omega)$

15. Take the linear displacement of m_2 as the coordinates of motion to determine the equivalent stiffness k_B and equivalent mass m_B of the system and natural frequency of vibration. Each value in the figure is known, regardless of the mass of the horizontal lever and the distributed mass of the elastic element.

Solution:

$U_a = \frac{k_1}{2} x_1^2 + \frac{k_2}{2} x_2^2 \quad U_e = \frac{k_{eq}}{2} x^2$

$x_1 = \frac{a_2}{a_4} x \quad x_2 = \frac{a_3}{a_4} x$

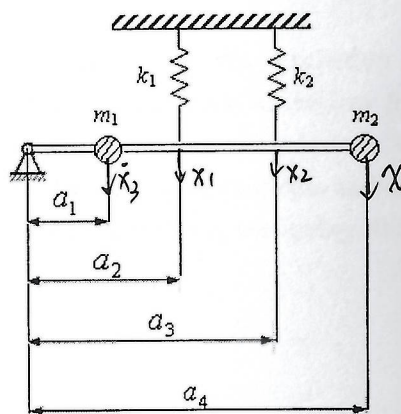
$U_a = U_e \quad \frac{a_2^2}{a_4^2} k_1 + \frac{a_3^2}{a_4^2} k_2 = k_{eq}$

$T_a = \frac{1}{2} m_2 \dot{x}^2 + \frac{1}{2} m_1 \dot{x}_3^2$

$T_e = \frac{1}{2} m_e \dot{x}^2 \quad \text{and} \quad \dot{x}_3 = \frac{a_1}{a_4} \dot{x}$

$m_e = m_2 + m_1 \frac{a_1^2}{a_4^2}$

$p = \sqrt{\frac{k_e}{m_e}} = \sqrt{\frac{a_2^2 k_1 + a_3^2 k_2}{m_2 a_4^2 + m_1 a_1^2}}$



试卷装订线
BINDING LINE
装订线内不要答题, 不要填写考生信息
试卷装订线
BINDING LINE

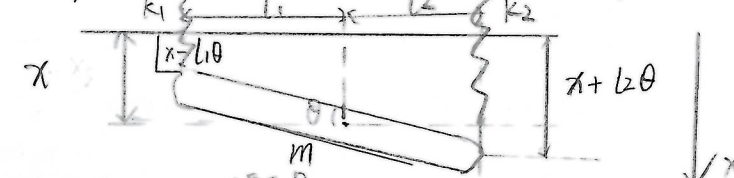
得分
Score

V. Comprehensive problem-solving questions (15 points)

16. There are two methods to simplify the car into a two-degree-of-freedom vibration system model in the course. Draw the diagrams of two-degree-of-freedom vibration system models under the two methods; write down their respective assumptions for simplification and explain the physical meaning of each value in the diagrams. If you want to analyze the deformation and dynamic load of suspension and tire under irregular road (displacement) excitation, which two-degree-of-freedom model is best used? Deduce the corresponding vibration differential equation of this model.

Solution.

① 简化条件 不考虑车辆侧倾、弹簧下面质量及减振器影响



m - 质量

x - 重心位移

θ - 倾角

l_1 - 左轴距重心距离

l_2 - 右轴距重心距离

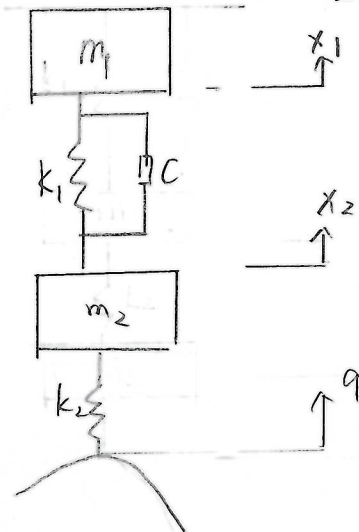
k_1, k_2 - 各自刚度

$m\ddot{x} + k_1(x - l_1\theta) + k_2(x + l_2\theta) = 0$

$J\ddot{\theta} + k_1 l_1(x - l_1\theta) - k_2 l_2(x + l_2\theta) = 0$

②

简化条件: 前后悬架之间互不影响、悬挂质量分配系数为1.



m_1 - 簧质量

m_2 - 簧下质量

k_1, k_2 - 各自刚度

c - 阻尼系数

x_2, x_1 - 位移

q - 外界引起的位移

$m_1 \ddot{x}_1 + k_1(x_1 - x_2) + c(\dot{x}_1 - \dot{x}_2) = 0$

$m_2 \ddot{x}_2 + k_1(x_2 - x_1) + c(\dot{x}_2 - \dot{x}_1) + k_2(x_2 - q) = 0$

最好先用第二个模型