

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

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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	二	三	四	五	六	七	八	九	十	合计	Teacher
Full score											100	
Score	8	20	16	28	10						82	

得分	8
Score	

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. (B) 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	20
Score	

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

6. Sample function

答: 在随机过程中, 任意选取一个函数, 这个函数叫做样函数。

7. Multi-degree-of-freedom vibration system

答: 在系统振动过程中, 用多个(2个以上)空间坐标表示系统位置的系统。

8. Power spectrum

5 功率谱是功率的密度曲线，也叫自谱。

9. Spectral analysis

0 在功率谱曲线上~~任意点~~，通过求该点的平均功率，得到相对应的自功率密度函数。

10. Principle of dynamic vibration absorber

5 答：原理：不消耗能量，依靠附加在弹性系统上的物质质量，作用在系统产生方向相反，大小相等的力来抵消振动，使系统振动。

得分
Score

16

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.

8 答：异同点：主动隔离震源来自机器本身，避免影响仪表等。
被动隔离震源来自支座或基础，避免影响机器本身。

相同点：都采取加弹簧和阻尼器来隔离震源。

评价标准不同：主动隔离以力传递率来评价
被动隔离以位移传递率来评价。

相同点。

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

8 答：脉冲响应函数是作用于时间域上；用来描述振动系统的状态参数。

频率响应函数是作用于频谱域上，由响应函数除以激励函数。

关系：
$$Y(\omega) = H(\omega)X(\omega)$$

得分
Score

28

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).

10 由
$$F(x) = \int_{-\infty}^{\infty} p(x) dx = \int_{-\infty}^{\infty} ae^{-b|x|} dx = 1$$

$$= \int_{-\infty}^0 ae^{bx} dx + \int_0^{\infty} ae^{-bx} dx$$

$$= \frac{a}{b} e^{bx} \Big|_{-\infty}^0 - \frac{a}{b} e^{-bx} \Big|_0^{\infty}$$

$$= \frac{2a}{b} = 1$$

$$\Rightarrow 2a = b$$

$$\text{当 } a=1 \text{ 时, } b=2.$$

$$x \leq 0 \text{ 时}$$

$$F(x) = \int_{-\infty}^x e^{2s} ds = \frac{1}{2} e^{2x}$$

$$x > 0 \text{ 时}$$

$$F(x) = F(0) + \int_0^x e^{-2s} ds = \frac{1}{2} - \frac{1}{2} e^{-2x} + \frac{1}{2} = 1 - \frac{1}{2} e^{-2x}$$

30 拉拔力: 8800N (60)

8

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

解: $R(x) = 25e^{-4|x|} \cos \omega x + 16$

$$\mu(x) = \lim_{\tau \rightarrow \infty} R(x) = 16$$

$$\mu(x) = \sqrt{16} = \pm 4$$

$$E(x^2) = \lim_{\tau \rightarrow 0} R(x) = 41$$

$$\sigma_x^2 = E(x^2) - \mu^2(x) = 41 - 16 = 25$$

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

$$= \int_{-\infty}^{\infty} 25 e^{-4|\tau|} \cos \omega \tau e^{-j\omega\tau} d\tau = ?$$

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.

解: 由能量法, 设 m_2 位移为 x_2 , 速度为 $\dot{x}_2$

$$U_a = U_e = \frac{1}{2} k_e x_2^2$$

$$U_a = \frac{1}{2} k_1 \left[\frac{a_1}{a_4} x_2 \right]^2 + \frac{1}{2} k_2 \left[\left(\frac{a_3}{a_4} \right) x_2 \right]^2$$

$$= \frac{1}{2} \left(\frac{k_1 a_1^2 + k_2 a_3^2}{a_4^2} \right) x_2^2$$

$$U_e = U_a$$

$$k_e = \frac{k_1 a_1^2 + k_2 a_3^2}{a_4^2}$$

$$T_a = T_e = \frac{1}{2} m_e \dot{x}_2^2$$

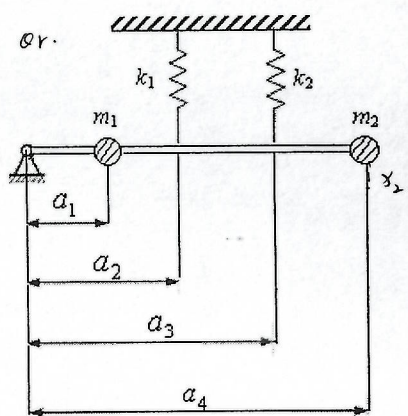
$$T_a = \frac{1}{2} m_1 \left(\frac{a_1}{a_4} \dot{x}_2 \right)^2 + \frac{1}{2} m_2 \cdot \dot{x}_2^2$$

$$= \frac{1}{2} \left(\frac{m_1 a_1^2}{a_4^2} + m_2 \right) \dot{x}_2^2$$

$$T_a = T_e$$

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

$$\text{固有频率 } \omega = \sqrt{\frac{k_e}{m_e}} = \sqrt{\frac{k_e}{\frac{a_1^2}{a_4^2} m_1 + m_2}} = \sqrt{\frac{k_1 a_1^2 + k_2 a_3^2}{a_1^2 m_1 + a_4^2 m_2}} \text{ rad/s}$$



..... 试卷装订线 装订线内不要答题, 不要填写考生信息 试卷装订线
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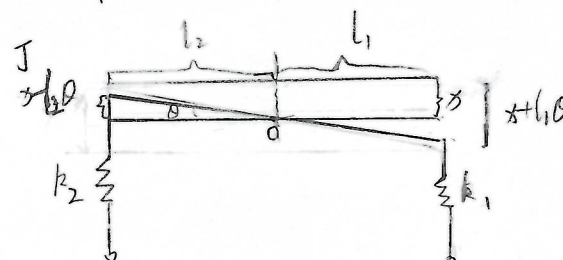
10

得分
Score 10

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.

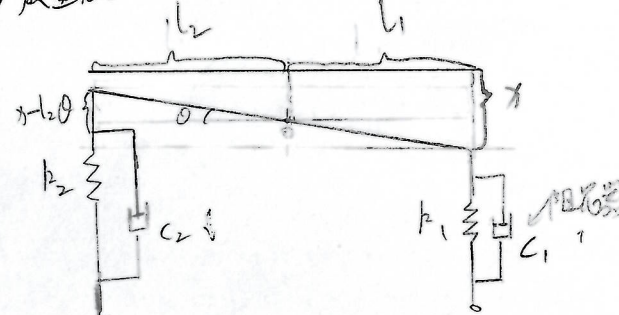
简化假设条件, 减小侧倾和横摆角, 以平衡位置为原点, 忽略弹簧
 (1) 忽略侧倾以下的质量和阻尼器的质量, 忽略阻尼



$$\begin{cases} m\ddot{x} + k_2(x-l_0) + k_1(x+l_0) = 0 \\ J\ddot{\theta} + k_2(x-l_0) \cdot l_2 - k_1(x+l_0) \cdot l_1 = 0 \end{cases}$$

k - 弹性刚度, J - 车体惯量
 x - 位移, θ - 车身前后倾角

(2) 质量与侧倾为 1, 弹性刚度为原点, 忽略阻尼



$$\begin{cases} m\ddot{x} + k_2(x-l_0) + k_1(x+l_0) + c_1\dot{\theta}l_1 = c_2\dot{\theta}l_2 \\ J\ddot{\theta} + k_2(x-l_0) \cdot l_2 - k_1(x+l_0) \cdot l_1 - c_1\dot{\theta}l_1 - c_2\dot{\theta}l_2 = 0 \end{cases}$$

不平路面激励, 最好用
 (2) 自由度模型