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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 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	6	4	7	30	7						54	

得分 Score	6
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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. (C) 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. (B) 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	4
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II. Explanation of phases (5 points *5=25 points)

6. Sample function

由各样本点组成的连续或离散的函数

7. Multi-degree-of-freedom vibration system

具有两个或两个以上自由度运动自由度的振动系统

8. Power spectrum

9. Spectral analysis

利用频谱分析振动特性。

10. Principle of dynamic vibration absorber

利用合适的系统特性主动隔振。

得分
Score

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.

主动隔振是指根据振动环境的特性，主动改变系统特性，系统结构特性，以控制系统的振动，达到隔振的目的。如电磁式主动悬架。

被动隔振是指预测可能的振动环境特性，设计一个不可变的、适宜的系统结构，以达到隔振的目的。如发动机空气支架。

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

频率响应函数 $H(\omega) = \frac{Y(\omega)}{X(\omega)}$ ，是响应与激励之比。

得分
Score

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 $F(x)$.

$$\begin{aligned} F(x) &= P\{X \leq x\} \\ &= P\{-\infty \leq X \leq x\} \\ &= \int_{-\infty}^x p(x) dx \\ &= \end{aligned}$$

$$\int_{-\infty}^{+\infty} p(x) dx = 1$$

$$\int_0^{+\infty} ae^{-bx} dx + \int_{-\infty}^0 ae^{bx} dx = 1$$

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

$$b = 2a$$

$$\begin{aligned} F(x) &= P\{X \leq x\} \\ &= P\{-\infty \leq X \leq x\} \\ &= \int_{-\infty}^x p(x) dx \\ &= \int_{-\infty}^x e^{-2|x|} dx \end{aligned}$$

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

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

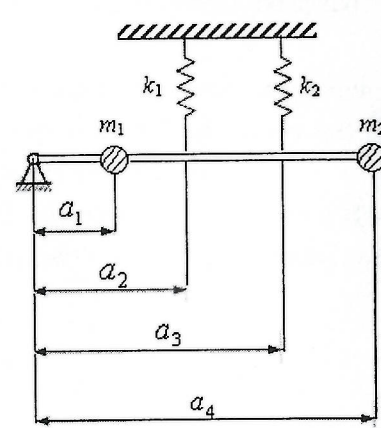
10

$$\begin{aligned} \mu(x) &= \lim_{T \rightarrow \infty} R_{xx}(0) = 16 \\ E[x^2] &= \lim_{T \rightarrow \infty} R_{xx}(0) = 41 \\ \sigma_x^2 &= E[x^2] - \mu^2(x) = 25 \\ S_x(\omega) &= \mathcal{F}[R_{xx}(\tau)] \\ &= \int_{-\infty}^{\infty} R_{xx}(\tau) e^{-i\omega\tau} d\tau \\ &= \int_{-\infty}^{\infty} 25e^{-4|\tau|} \cos \omega \tau e^{-i\omega\tau} d\tau + \int_{-\infty}^{\infty} 16 e^{-i\omega\tau} d\tau \\ &= \int_{-\infty}^{\infty} 25e^{-4|\tau|} \frac{e^{i\omega\tau} + e^{-i\omega\tau}}{2} e^{-i\omega\tau} d\tau + 32\pi\delta(\omega) \\ &= \int_{-\infty}^{\infty} \frac{25}{2} e^{-4|\tau|} (1 + e^{-2i\omega\tau}) d\tau + 32\pi\delta(\omega) \\ &= \frac{25}{4} + 32\pi\delta(\omega) + \frac{25}{4} \\ &= \frac{25}{4} + 32\pi\delta(\omega) + \frac{25}{4} \\ &= \frac{25}{4} + 32\pi\delta(\omega) + \frac{25}{4} \end{aligned}$$

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.

10

$$\begin{aligned} \therefore U_a &= U_e = \frac{1}{2} k_e x^2 \\ \therefore \frac{\partial U}{\partial x} &= \frac{\partial U}{\partial x} = \frac{1}{2} k_e x^2 \\ k_e &= 2 \left(\frac{\partial U}{\partial x} k_1 + \frac{\partial U}{\partial x} k_2 \right) \\ \therefore k_B &= 2 \left(\frac{\partial U}{\partial x} k_1 + \frac{\partial U}{\partial x} k_2 \right) \\ \therefore T_a &= T_e = \frac{1}{2} m_e x^2 \\ \therefore m_2 x^2 + \frac{\partial U}{\partial x} m_1 x^2 &= \frac{1}{2} m_e x^2 \\ \therefore m_B &= m_e = 2m_2 + \frac{\partial U}{\partial x} m_1 \end{aligned}$$



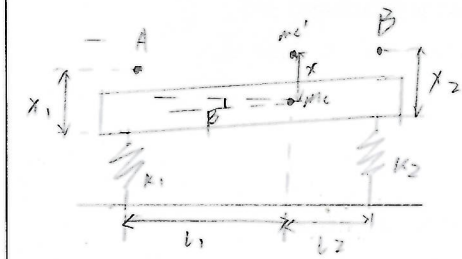
$$\begin{aligned} f &= \frac{P}{2\pi\nu} = \frac{1}{2\pi} \sqrt{\frac{k_B}{m_B}} = \frac{1}{2\pi} \sqrt{\frac{2 \left(\frac{\partial U}{\partial x} k_1 + \frac{\partial U}{\partial x} k_2 \right)}{2m_2 + \frac{\partial U}{\partial x} m_1}} \\ &= \frac{1}{2\pi} \sqrt{\frac{\alpha_2 k_1 + \alpha_3 k_2}{\alpha_4 m_2 + \alpha_1 m_1}} \end{aligned}$$

得分	7
Score	

V. Comprehensive problem-solving questions (15 points)

7

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.



m_c 重心
 l_1 前悬架至重心距离
 l_2 后悬架至重心距离
 x_1 前悬架压缩量
 x_2 后悬架压缩量
 β 倾角
 x 重心位移

$$\begin{cases} m\ddot{x} = \frac{k_1 x_1}{m \cdot \frac{l_1}{l_1 + l_2}} + \frac{k_2 x_2}{m \cdot \frac{l_2}{l_1 + l_2}} \\ J\ddot{\theta} = \frac{k_1 x_1 l_1}{m \cdot \frac{l_1^2}{l_1 + l_2}} + \frac{k_2 x_2 l_2}{m \cdot \frac{l_2^2}{l_1 + l_2}} \end{cases}$$