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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	5	12	30	10						63	

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

6. Sample function

一次随机实验的测试结果

7. Multi-degree-of-freedom vibration system

该振动系统的自由度高于1, 称为多自由度振动系统

8. Power spectrum

对一系列激励响应的描述

9. Spectral analysis

通过傅里叶变换对时域信号进行变换对功率谱分析。

10. Principle of dynamic vibration absorber

将振动通过弹性等阻尼元件转化吸收。

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.

答: 主动隔振与被动隔振, 都能减轻振动的危害,

不同点: 主动隔振一般通过主动一些改进如动力吸振器。

等主动隔振, 被动隔振则一般通过改进材料
使用隔振材料等。被动隔振, 一般主动隔振效果
比被动隔振效果好。

一般质量好的车, 隔振强, 底盘重量大, 被动隔振强,
主动隔振强。

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

函数描述描述系统特性
各频率响应的函数 $H(\omega) = \frac{1}{k - m\omega^2 + j c \omega}$ 这一函数统称 $H(\omega) = 1/h(\omega) e^{j\phi}$
脉冲响应函数 通常用 $h(t)$ 和 $Y(\omega)$ 表示。
 $X(\omega) = \int_{-\infty}^{\infty} h(t) e^{-j\omega t} dt$ $h(t) = \begin{cases} \frac{1}{m\omega} e^{j\omega t} & t > 0 \\ 0 & t < 0 \end{cases}$

频率响应函数和脉冲响应函数的关系
 $Y(\omega) = H(\omega) X(\omega)$
 $H(\omega) = \frac{Y(\omega)}{X(\omega)}$

得分
Score

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

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

解: 依题意 $\int_{-\infty}^{\infty} p(x) dx = 1$ $\int_{-\infty}^{\infty} a e^{-b|x|} dx = \int_{-\infty}^0 a e^{bx} dx + \int_0^{\infty} a e^{-bx} dx$
 $= \frac{a}{b} + \frac{a}{b} = \frac{2a}{b} = 1$

$b = 2a$

$a = 1 \Rightarrow b = 2$
 $p(x) = e^{-2|x|} = \begin{cases} e^{-2x} & x \geq 0 \\ e^{2x} & x < 0 \end{cases}$

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

$x \geq 0$ $F(x) = \int_{-\infty}^0 p(x) dx + \int_0^x e^{-2x} dx$
 $= 1 - \frac{1}{2} e^{-2x}$ $F(x) = \begin{cases} \frac{1}{2} e^{2x} & x < 0 \\ 1 - \frac{1}{2} e^{-2x} & x \geq 0 \end{cases}$

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

解: 依题意 $x \rightarrow \infty, R(x) \rightarrow E(x^2) = 41$
 $\mu(x) = 16$ $\mu(x) = \pm 4$
 $\sigma_x^2 = E(x^2) - \mu(x)^2 = 25$

$S_x(\omega) = \int_{-\infty}^{\infty} R(x) e^{-i\omega x} dx$
 $= \int_{-\infty}^{\infty} 25e^{-4|x|} \cos \omega x e^{-i\omega x} dx + 16 \int_{-\infty}^{\infty} e^{-i\omega x} dx$
 $= \frac{25}{4} \cdot \frac{25\omega^2}{4\omega^2 + 25} + 32\pi\omega$

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.

解: $V_e = \frac{1}{2} k_1 \left(\frac{a_2}{a_4} l \right)^2 + \frac{1}{2} k_2 \left(\frac{a_3}{a_4} l \right)^2$

$V_e = \frac{1}{2} k_B l^2$

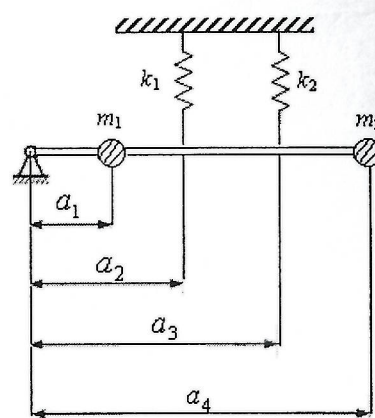
$k_B = \frac{a_2^2 k_1 + a_3^2 k_2}{a_4^2}$

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

$W = \frac{1}{2} m_B \dot{x}^2$

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

固有频率 $f = \frac{1}{2\pi} \sqrt{\frac{k_B}{m_B}} = \frac{1}{2\pi} \sqrt{\frac{a_2^2 k_1 + a_3^2 k_2}{m_1 a_1^2 + m_2 a_4^2}}$

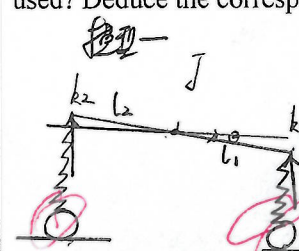


BINDING LINE 试卷装订线 装订线内不要答题, 不要填写考生信息 试卷装订线 BINDING LINE

得分 10
Score

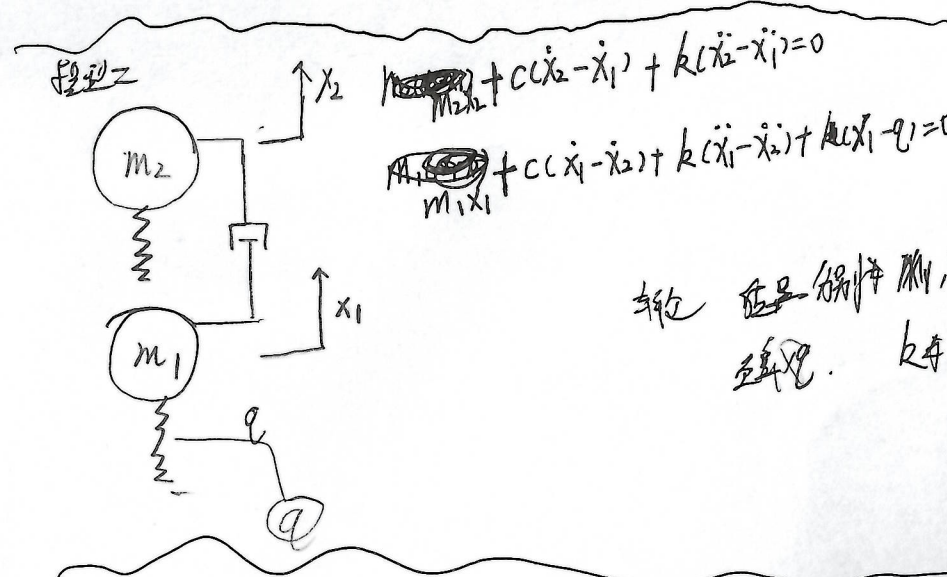
V. Comprehensive problem-solving questions (15 points)

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.



$J\ddot{\theta} = k_1(l_1 - l_0) + k_2(l_2 + l_0)$
 $J\ddot{\theta} = k_1(l_1 - l_0) - k_2(l_2 + l_0)$

汽车振动时悬架变形, $\theta \approx 0$
 k_1, k_2 弹簧刚度
 l_1, l_2 悬架支点到两端距离
 l_0 悬架在平衡位置时的长度



$m_2\ddot{x}_2 + c(\dot{x}_2 - \dot{x}_1) + k(x_2 - x_1) = 0$
 $m_1\ddot{x}_1 + c(\dot{x}_1 - \dot{x}_2) + k(x_1 - x_2) + k_0 x_1 = 0$

轮胎 悬架 解耦, m_2 位移为 x_1, x_2
 k_0 刚度

分析 激励下悬架和轮胎的振动情况
 模型一: 两自由度模型