

# Master-Program Mechatronic and cyber-physical Systems CHAM Sample Problems for Preparation of the Admission Test

The following collection of problems and test questions shall give applicants opportunity to make themselves familiar with the **contents** and **level** of the admission test for the Master-Program Mechatronic and cyber-physical systems at Deggendorf Institute of Technology - study side Cham.

The problems also represent the range of basic subjects which are considered elementary, prerequisite knowledge to participate successfully in the Master-Program.

## A) Mathematics

A1 (20 minutes)

Let  $a, x \in \mathbb{R}$ ,  $a \neq 0$ . Calculate the derivative of

$$f(x) = \underbrace{\frac{1}{4a^3\sqrt{2}} \ln\left(\frac{x^2 + ax\sqrt{2} + a^2}{x^2 - ax\sqrt{2} + a^2}\right)}_{=:g(x)} + \underbrace{\frac{1}{2a^3\sqrt{2}} \arctan\left(\frac{ax\sqrt{2}}{a^2 - x^2}\right)}_{=:h(x)}$$

and simplify as far as possible. Hint: The final expression is surprisingly simple. Approximately half of the points are for simplifying. Differentiate and simplify  $g(x)$  and  $h(x)$  separate as far as possible.  $\ln$  means the natural logarithm.

$$\text{Final answer: } g'(x) = \frac{1}{2a^2} \frac{a^2 - x^2}{a^4 + x^4}, \quad h'(x) = \frac{1}{2a^2} \frac{a^2 + x^2}{a^4 + x^4}, \quad f'(x) = \frac{1}{a^4 + x^4}$$

A.2) (6 minutes)

Decompose  $\frac{x^4 + x^3 - x - 1}{(x-1)(x^3 + x)}$  into real partial fractions.

$$\text{Final answer: } 1 + \frac{1}{x} + \frac{x+1}{x^2+1}.$$

**B) Physics**

B.1)

The potential energy of an object is given by  $U(x)=8x^2-x^4$ , where  $U$  is in joules and  $x$  is in meters.

- a) Determine the force acting on this object.
- b) At what positions is this object in equilibrium?
- c) Which of these equilibrium positions are stable and which are unstable?

B.2)

A block of mass  $m$  is dropped onto the top of a vertical spring whose force constant is  $k$ . If the block is released from a height  $h$  above the top of the spring,

- a) what is the maximum energy of the block?
- b) What is the maximum compression of the spring?
- c) At what compression is the block's kinetic energy half its maximum value?

B.3)

Two point masses  $m_1$  and  $m_2$  are separated by a massless rod of length  $L$ .

- a) Write an expression for the moment of inertia about an axis perpendicular to the rod and passing through it at a distance  $x$  from mass  $m_1$ .
- b) Calculate  $dI/dx$  and show that  $I$  is at a minimum when the axis passes through the center of mass of the system.

B.4)

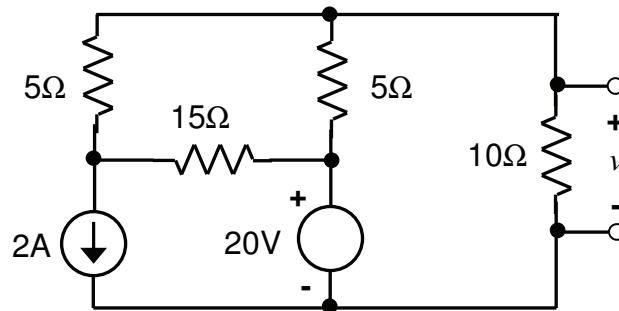
A harmonic wave with a frequency of 80Hz and an amplitude of 0.025m travels along a string to the right with a speed of 12m/s.

- a) Write a suitable wave function for this wave.
- b) Find the maximum speed of a point on the string.
- c) Find the maximum acceleration of a point on the string.

### C) Basics of Electrical Engineering

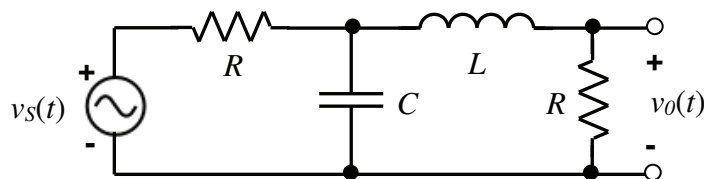
#### C.1) DC Circuit Analysis

Find voltage  $v$  in the given DC circuit.



#### C.2) Sinusoidal Steady-State Analysis

Take into account that  $R = \omega L = \frac{1}{\omega C}$  and therefore  $\omega = \frac{1}{\sqrt{LC}}$  and  $R = \sqrt{\frac{L}{C}}$ . The voltage source is  $v_s(t) = \hat{v} \cdot \sin \omega t$ .

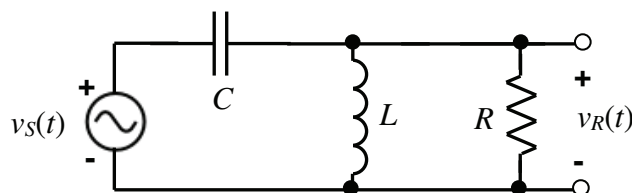


a) Calculate the transfer function  $T(s) = \frac{V_0(s)}{V_s(s)}$ .

b) Calculate  $v_0(t)$ .

#### C.3) Sinusoidal Steady-State Analysis

Take into account that  $R = \omega L = \frac{2}{\omega C}$ . The voltage source is  $v_s(t) = \hat{v} \cdot \sin \omega t$ .

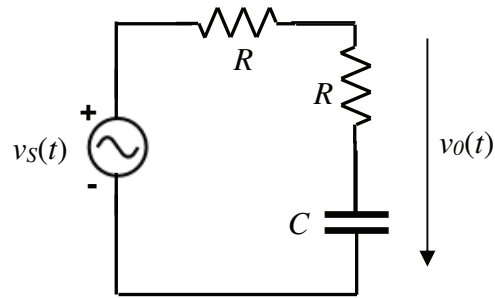


a) Calculate the transfer function  $T(s) = \frac{V_R(s)}{V_s(s)}$ .

b) Calculate  $v_R(t)$ .

## C.4) Bode plot

Determine the frequency response (Bode plot) of the transfer function  $T(s) = \frac{V_o(s)}{V_s(s)}$ .



**D) Informatics**

E.1) How many memory cells are necessary to save a byte? Choose the correct answer.

- 1
- 2
- 4
- 8
- 16
- 32

D.2) Add two binary numbers:  $1001 + 0011$  and give the result as a decimal value!

**E) Control technology and system technology****F.1) Which transfer function describes an integration in the Laplace domain?**

- $F(s) = 1$
- $F(s) = 1/(1 + s)$
- $F(s) = 1/s$
- $F(s) = s$

**E.2) How would you describe a linear, dynamic system?**

- by a simple algebraic equation
- by a linear differential equation with constant coefficients
- by a first-order differential equation
- by a characteristic function