Master-Program
Mechatronic and cyber-physical Systems DEG
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.
The problems also represent the range of basic subjects which are considered elementary, prerequisite knowledge to participate successfully in the MasterProgram.

A) Mathematics

A1 (20 minutes)
Let $a, x \in \mathbb{R}, a \neq 0$. Calculate the derivative of

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

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.

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

A.2) (6 minutes)
Decompose $\frac{x^4 + x^3 - x - 1}{(x-1)(x^3 + x)}$ into real partial fractions.

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.

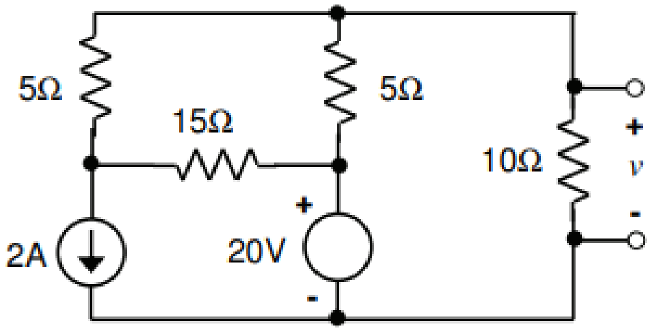
b) Find the maximum speed of a point on the string.

c) Find the maximum acceleration of a point on the string.

C) Basics of Electrical Engineering

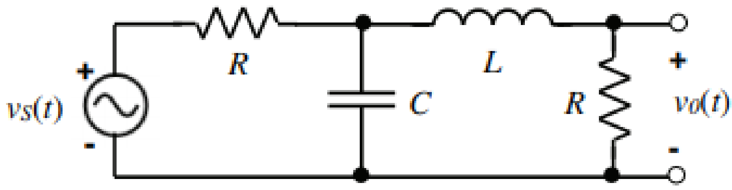
C.1) DC Circuit Analysis

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 $v_S(t) = \hat{v} \cdot \sin \omega t$.

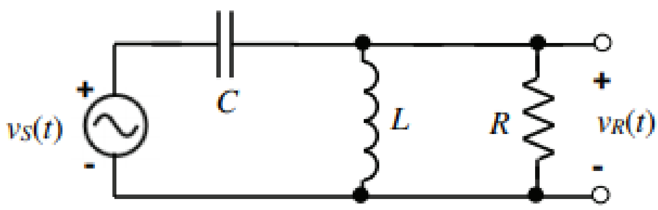


a) Calculate the transfer function $T(\underline{s}) = \frac{V_0(\underline{s})}{V_S(\underline{s})}$.

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 $v_S(t) = \hat{v} \cdot \sin \omega t$.

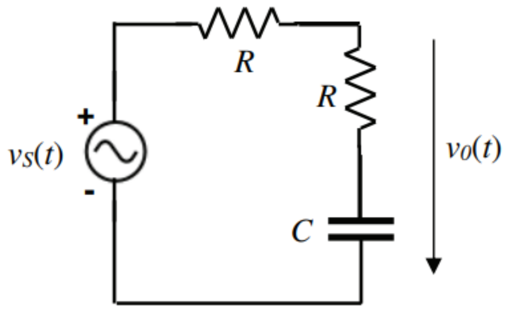


a) Calculate the transfer function $T(\underline{s}) = \frac{V_R(\underline{s})}{V_S(\underline{s})}$.

b) Calculate $v_R(t)$.

C.4) Bode plot

Determine the frequency response (Bode plot) of the transfer function $T(\underline{s}) = \frac{\underline{V}_0(\underline{s})}{\underline{V}_S(\underline{s})}$.



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