

Master-Program of Electrical Engineering and Information Technology

Sample Problems for Preparation of the Admission Test

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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 of Electrical Engineering and Information Technology at Deggendorf University of Applied Sciences.

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

A) Mathematics

A.1) (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) Electrostatics

C.1) A test charge of 10^{-6}C is placed halfway between a charge of $5 \cdot 10^{-6}\text{C}$ and a charge of $3 \cdot 10^{-6}\text{C}$ that are 20 cm apart. Find the magnitude and direction of the force on the test charge.

C.2 a) Two parallel wires 20 cm apart carry currents in the *same* direction of 10 A. What is the magnetic field halfway between them? Is there a force acting on the wires and when this is the case what is the direction of the force? Draw qualitatively the magnetic field lines of the magnetic field of each single wire and draw the magnetic field lines of the total magnetic field of the two wires. Give a detailed explanation for your answer.

C.2 b) Two parallel wires 20 cm apart carry currents in opposite directions of 10 A. Is there a force acting on the wires and when this is the case what is the direction of the force? Is there a point on the connecting line between the two wires where the magnetic field is zero and when this is so, where is that point.

C.3 a) A square wire loop 8 cm on a side is perpendicular to a magnetic field of $5 \cdot 10^{-3}\text{T}$.

C.3 b) Calculate the magnetic flux through the loop?

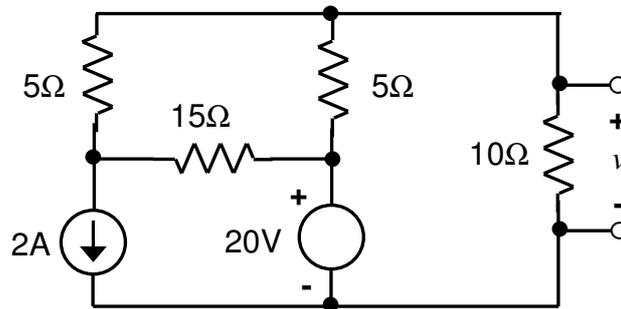
C.3 c) The field drops to 0 in 0.1s. Calculate the average emf which is induced in the loop during this period of time?

C.4) Given two charges q_1 and q_2 . Both are positive and q_2 is three times as large as q_1 . Additionally there is given a test charge q_0 which is placed in between charge q_1 and q_2 . Where has the charge to be placed so that the net force on the test charge is zero?

D) Basics of Electrical Engineering

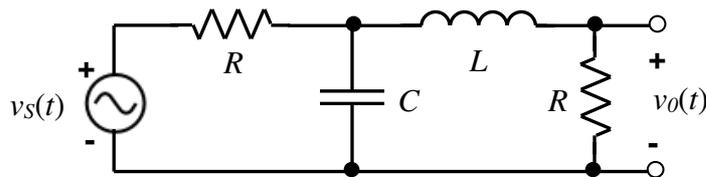
D.1) DC Circuit Analysis

Find voltage v in the given DC circuit.



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

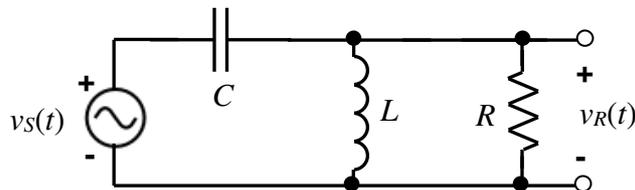


a) Calculate the transfer function $T(s) = \frac{V_o(s)}{V_s(s)}$.

b) Calculate $v_o(t)$.

D.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 $v_R(t)$.

D.4) Bode plot

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

