Admission Exam PPG-EM – 2022/1º sem

Candidate Name:
ID:
Date:
Signature:

Instructions:

1) The admission exam will be held on December 5, 2021, online, from 9:00 am to 10:00 am (Brasília time). The test will be available at 8:55 am (Brasília time), on the Program website (http://www.ppg-sem.eesc.usp.br/) and on the registration website (http://ppgselecao.eesc .usp.br/).

2) The exam consists of 10 questions, and the candidate must select 5 questions to solve. In case the candidate solves a larger number of questions, only the first 5 will be considered;

3) All questions have the same value (2.0 points for each QUESTION);

4) The candidate must send to the e-mail: ps_posgrem@eesc.usp.br, a scanned copy of the test resolution, in accordance with the following instructions:
- if possible, print the test and answer the questions in the specified fields;
- if it is not possible to print the proof, indicate the QUESTION number and answer it on, at most, an A4 sheet;
- all questions must be answered in your own handwriting;
- all answer sheets must contain the student's name and signature;
- send a single document, in .pdf format, containing all the answer sheets.

5) Only the resolutions that comply with all instructions in the notice and that are sent by e-mail (ps_posgrem@eesc.usp.br), with delivery time **until 10:15 am** (Brasilia time), will be considered suitable for correction.

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QUESTION 1: (Linear Algebra)

Considering the matrices **A** and **B** defined below, determine the eigenvalues, λ_1 and λ_2, and eigenvectors, $\mathbf{v}_1$ and $\mathbf{v}_2$, corresponding to the generalized eigenvalue problem $\lambda\mathbf{B}\mathbf{v} = \mathbf{A}\mathbf{v}$. Normalize the eigenvectors such that $|\mathbf{v}_1| = |\mathbf{v}_2| = 1$.

$\mathbf{A} = \begin{bmatrix} 3 & -2 \\ -2 & 4 \end{bmatrix}$ and $\mathbf{B} = \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix}$

Justify your answer in the checkered area.

Answer:

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QUESTION 2: (Differential and Integral Calculus)

Find the limit, if any:

$$\lim_{x \to 0} \left(\frac{1 - \cos x}{\operatorname{sen} x} \right)$$

Justify your answer in the checkered area.

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QUESTION 3: (Computation)

Select one of the options below, analyze the code and indicate the expected output.

Option 1: Code referring to an abstract data structure implemented in C programming language.

```c

#include <stdio.h>
#include <stdlib.h>

struct no
{   int data;
    struct no *right_filho;
    struct no *left_filho;
};

struct no* search(struct no *raiz, int x)
{   if(raiz==NULL || raiz->data==x)
        return raiz;
    else if(x>raiz->data)
        return search(raiz->right_filho, x);
    else
        return search(raiz->left_filho,x);
}

struct no* find_minimum(struct no *raiz)
{   if(raiz == NULL)
        return NULL;
    else if(raiz->left_filho != NULL)
        return find_minimum(raiz->left_filho);
    return raiz;
}

struct no* new_no(int x)
{   struct no *p;
    p = malloc(sizeof(struct no));
    p->data = x;
    p->left_filho = NULL;
    p->right_filho = NULL;
    return p;
}

struct no* insert(struct no *raiz, int x)
{   if(raiz==NULL)
        return new_no(x);
    else if(x>raiz->data)
        raiz->right_filho = insert(raiz->right_filho, x);
    else
        raiz->left_filho = insert(raiz->left_filho,x);
    return raiz;
}

struct no* apague(struct no *raiz, int x)
{   if(raiz==NULL)
        return NULL;
    if (x>raiz->data)
        raiz->right_filho = apague(raiz->right_filho, x);
    else if(x<raiz->data)
        raiz->left_filho = apague(raiz->left_filho, x);
    else
    {
        if(raiz->left_filho==NULL && raiz->right_filho==NULL)
        {   free(raiz);
            return NULL;
        }

        else if(raiz->left_filho==NULL || raiz->right_filho==NULL)
        {   struct no *temp;
            if(raiz->left_filho==NULL)
                temp = raiz->right_filho;
            else
                temp = raiz->left_filho;
            free(raiz);
            return temp;
        }

        else
        {   struct no *temp = find_minimum(raiz->right_filho);
            raiz->data = temp->data;
            raiz->right_filho = apague(raiz->right_filho, temp->data);
        }
    }
    return raiz;
}

void manipule(struct no *raiz)
{   if(raiz!=NULL)
    {   manipule(raiz->left_filho);
        printf(" %d ", raiz->data);
        manipule(raiz->right_filho);
    }
}

int main()
{   struct no *raiz;
    raiz = new_no(20);
    insert(raiz,5);
    insert(raiz,1);
    insert(raiz,15);
    insert(raiz,9);
    insert(raiz,7);
    insert(raiz,12);
    insert(raiz,30);
    insert(raiz,25);
    insert(raiz,40);
    insert(raiz, 45);
    insert(raiz, 42);

    manipule(raiz);
    printf("\n");

    raiz = apague(raiz, 1);
    raiz = apague(raiz, 40);
    raiz = apague(raiz, 45);
    raiz = apague(raiz, 9);

    manipule(raiz);
    printf("\n");

    return 0;
}
```

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Option 2: Code referring to an abstract data structure implemented in Python programming language.

```
class Node:
    """ Implements a node from the tree"""
    def __init__(self, data):
        self.data = data
        self.left = None
        self.right = None

class BinarySearchTree:
    """ Implements a binary search tree"""
    def __init__(self, data):
        self.parent_node = Node(data)
        self.list_parent_nodes = [self.parent_node]

    def insert(self, new_node):
        parent = self.parent_node

        while True:
            if new_node.data > parent.data:
                if parent.right == None:
                    parent.right = new_node
                    if parent not in self.list_parent_nodes:
                        self.list_parent_nodes.append(parent)
                    break
                else:
                    parent = parent.right
            elif new_node.data < parent.data:
                if parent.left == None:
                    parent.left = new_node
                    if parent not in self.list_parent_nodes:
                        self.list_parent_nodes.append(parent)
                    break
                else:
                    parent = parent.left
            else:
                print("Esse nó já existe!")

    def print_tree(self):
        for parent in self.list_parent_nodes:
            print('Parent node:', parent.data)
            print('Left Node:', parent.left.data if parent.left !=None else None)
            print('Right Node:', parent.right.data if parent.right != None else
            None)
            print('\n')

def shift_binary_number_left(binary):
    """ Shifts all bits to the left by one place and adds a zero to the right """
    return int(binary << 1)

def main():
    tree = BinarySearchTree(shift_binary_number_left(3)) # b'0011'
    tree.insert(Node(shift_binary_number_left(1))) # b'0001'
    tree.insert(Node(shift_binary_number_left(4))) # b'0100'
    tree.insert(Node(shift_binary_number_left(2))) # b'0010'
    tree.print_tree()

if __name__ == "__main__":
    main()
```

Justify your answer in the checkered area.

Answer (Indicate the selected option):

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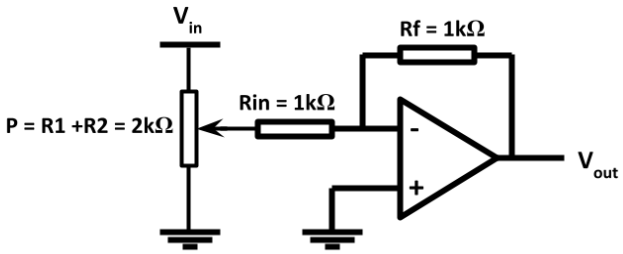
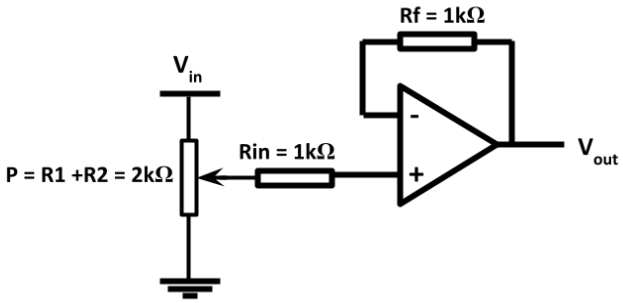
QUESTION 4: (Electronics)

In the circuits below, a potentiometer **P** has been placed to adjust the output voltage level $\mathbf{V_{out}}$. Regardless of the sign (positive or negative) of the output voltage, which of the two circuits will result in a linear adjustment of $\mathbf{V_{out}}$ as a function of the value of **R2**? Assume that **P** is a composition of two resistors (**R1** and **R2**), that **R2** varies linearly with the potentiometer's position setting, and that the operational amplifier is an ideal component.

1



2



Justify your answer in the checkered area.

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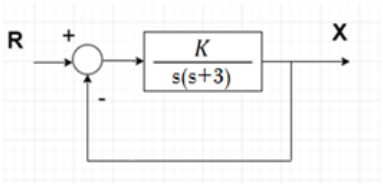
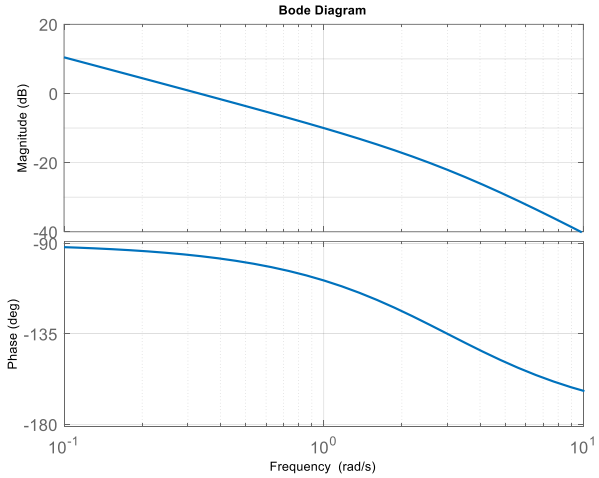
QUESTION 5: (Control Systems)

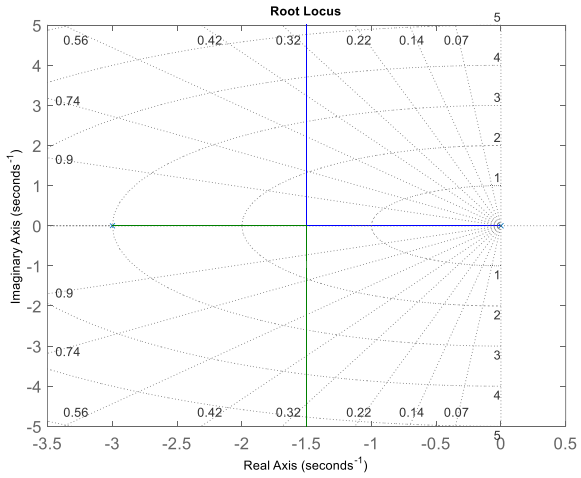
In the Root Locus diagram below, highlight the roots of this closed-loop system (see the block diagram) that guarantee a Phase Margin higher than 45°. The Bode diagram of the Transfer Function:

$$P(s) = \frac{1}{s(s+3)}$$

is also illustrated.







Justify your answer in the checkered area.

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QUESTION 6: (Materials)

Calculate the number of atoms effectively contained in the unit cell and the number of slip systems for dislocation gliding in the crystal structure present in the steel AISI 310.

Justify your answer in the checkered area.

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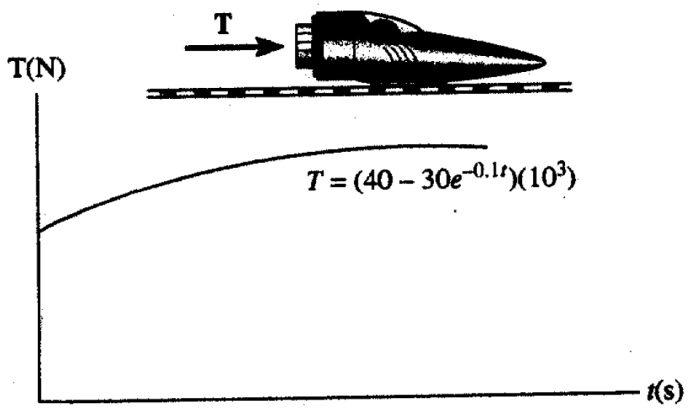
QUESTION 7: (General Mechanics)

Consider a jet-powered sled with a mass of $3 * 10^3$ kg that initially is at rest. Since the engine produces a horizontal thrust given by the figure below, determine the speed of the sled after 4 s. Present the necessary hypotheses for the solution of the problem.



Justify your answer in the checkered area.

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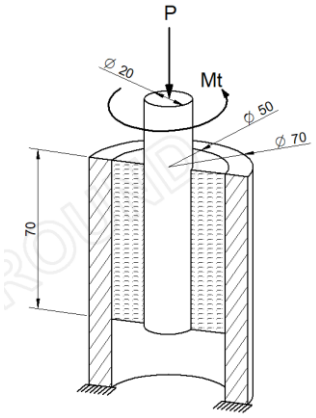
QUESTION 8: (Solid Mechanics)

A metallic drilled cylinder is joined to a metallic shaft by a thick rubber (centered) as shown in section below.

a) Determine the shear stress in the rubber as a function of the radius when an axial load on the shaft (P) of 2000N is applied.

b) Determine the shear stress in the rubber as a function of the radius when a shaft torque (Mt) of 20 N.m is applied.



Answer:

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QUESTION 9: (Thermodynamics)

A compressor admits 340 m^3/min of air at 95 kPa and 25 °C at its inlet with negligible speed. The compressor discharges compressed air at 200 kPa and 120 °C through an outlet with a cross-sectional area equal to 0.025 m^2. Heat is transferred from the compressed air at a rate equal to 60 kJ/min. Determine the input power required to drive the compressor in kW. Consider air as an ideal gas with R_{ar}=287 J/(kg*K) and c_p=1008 J/(kg*K).

Ideal gas relations: $p\forall = mR_gT \qquad dh = c_p dT$

Energy Conservation: $\dot{Q} = \frac{dE}{dt} + \sum_{sai}\left(h + \frac{V^2}{2} + gz\right) - \sum_{ent}\left(h + \frac{V^2}{2} + gz\right) + \dot{W}$

.

The total energy is given by: $E = U + EC + EP$

Where: p – pressure, $\forall$ – volume, V – velocity, m – mass, t – time, T – temperature, U – total internal energy, EC – total kinetic energy, EP – total potential energy, $\dot{Q}$ – heat transfer rate, $\dot{W}$ – power, h – specific enthalpy, R_g – gas constant, z – height, g – gravitational acceleration, and c_p – specific heat at constant pressure.

The subscripts represent: sai – outlets and ent - inlets.

Justify your answer in the checkered area.

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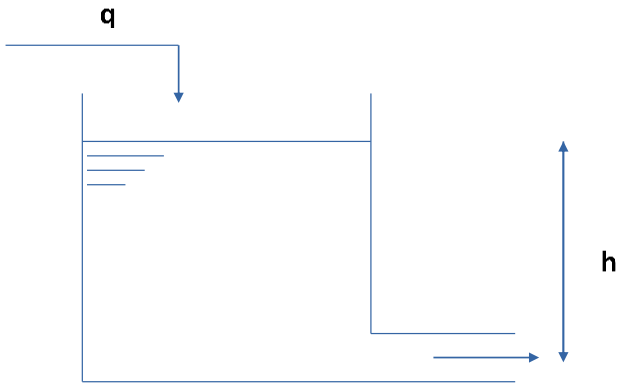
QUESTION 10: (Fluid Mechanics)

Consider a tank into which water enters at a volumetric flow **q**. There is also a water outlet where the volumetric flow is proportional to **h** (ie, **αh**), where **h** is the level of the tank. The tank has base area **A** and starts with height $\mathbf{h_o}$. Calculate the expression of the tank level with as a function of time, **h(t).**



$$\frac{d}{dt}\int_{VC}\rho d\forall+\int_{SC}\rho(\vec{V}\cdot\vec{n})dA=0$$

$$\frac{d}{dt}\int_{VC}\rho\vec{V}\,d\forall+\int_{SC}\rho\vec{V}(\vec{V}\cdot\vec{n})dA+\vec{a}_{ref}\int_{VC}\rho d\forall=\vec{F}$$

Justify your answer in the checkered area.

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