PROGRAMA DE PÓS-GRADUAÇÃO EM ENGENHARIA MECÂNICA

UNIVERSIDADE FEDERAL DE MINAS GERAIS

Escola de Engenharia

Prova de seleção de candidatos 2023/1

Orientações - LEITURA OBRIGATÓRIA:

- Esta prova terá duração de 120 minutos, contados a partir do horário de início de sua realização;
- A prova é composta por 20 questões de múltipla escolha com 5 opções (A, B, C, D e E);
- O candidato deve marcar uma opção por questão, somente;
- É obrigatório o preenchimento da última folha, intitulada FOLHA DE RESPOSTAS;
- A correção da prova será feita com base no que estiver apresentado na FOLHA DE RESPOSTAS, nada mais;
- Não é permitido desgrampear a prova, sob pena de desclassificação;
- Ao final da prova, é obrigatória a devolução de todas as páginas desta prova;
- É obrigatória a assinatura nesta página, confirmando a leitura destas orientações, e a concordância com o disposto;
- Todo o conteúdo da prova está em língua inglesa.

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Assinatura do candidato

Question 1

A perfectly spherical balloon is being filled with water at a constant rate of π liters/min. What is the time rate of change of the balloon's radius when its volume is $\frac{4}{3}\pi$ liters? Information (if needed): The volume, *V*, of an sphere of radius *R* is given by: $V = \frac{4}{3}\pi R^3$, 1 liter = $1000 cm^3$.

a) $\frac{10}{3}\pi$ cm/minute

b) 10 cm/minute

c) 2,5 π cm/minute

d) 10 π cm/minute

e) 2,5 cm/minute

Question 2

A car starts from rest (t=0) with an acceleration in m/s^2 given by: $a(t) = 6t + \frac{1}{(1+t)^2}$, where t is in seconds. Determine the distance traveled by this car in t=2 seconds.

a) 8 - *ln*(3) meters

b) 10 + *ln*(3) meters

c) 10 – *ln*(3) meters

d) 8 + *ln*(3) meters

e) 8 meters

Question 3

The equation $2x^3+x^2-1=0$ has one real root. For this equation, the Newton-Raphson formula can be written:

a) $x_{n+1}= (4x_n^3 + x_n^2 + 1)/(6x_n^2 + 2 x_n)$

b) $x_{n+1}= (2x_n^3 + x_n^2 - 1)/(6x_n^2 + 2 x_n)$

c) $x_{n+1}= 6x_n^2 + 2 x_n$

d) $x_{n+1}= -(2x_n^3 + x_n^2 - 1)/(6x_n^2 + 2 x_n)$

e) none of the above

Question 4

The strength of a filet weld is controlled by:

a) Concavity of weld deposit
b) Leg length
c) Effective Throat
d) Convexity of weld deposit
e) Theoretical Throat

Question 5

As far as hole-making processes are concerned, assess the following statements

I. boring can only be performed in hollow workpieces

II. deburring is often required after drilling through holes

III. gun drilling is employed to produce deep holes

IV. trepanning requires more power than drilling to produce a hole with the same diameter

The following statements are correct:

a) I e IV
b) I e II
c) I, II e III
d) III e IV
e) II, III e IV

Question 6

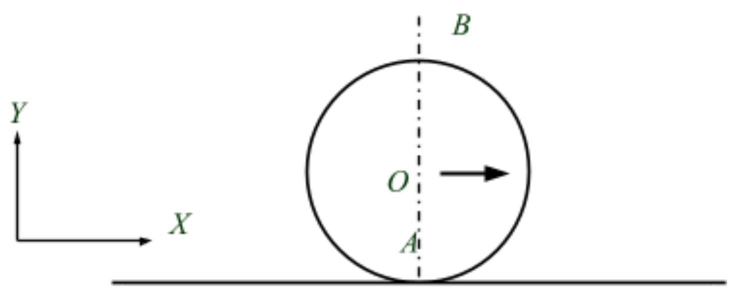
Mark the correct alternative with respect to Submerged Arc Welding process

a) The major limitation is the flux
b) It is only used in a workshop
c) Produces a melt pool with a relatively small volume
d) The filler metal is supplied only in the form of solid wires
e) Multiple electrodes cannot be used

Question 7

A rigid circular disc of radius R rolls without slipping on a flat surface, as it can be seen in the figure below. In this figure, point A indicates the contacting point between the disc and the surface, point O is the disc mass center, and point B is the highest vertical point of the disc. The unit vectors associated with the inertial frame are given by i along X-axis, j along Y-axis, and k along Z-axis. If the velocity vector of the disc mass center is V.i, compute the velocity vector of point B and acceleration vector of point A. Mark the alternative that shows the expressions of the velocity vector of point B and acceleration vector of point A, respectively. (HINT: The expressions of the relative motion of two points A and B from the Kinematics of rigid bodies are given by

$\vec{V}_B = \vec{V}_A + \vec{\omega} \times \vec{\rho}_{AB}$ and $\vec{a}_B = \vec{a}_A + \dot{\vec{\omega}} \times \vec{\rho}_{AB} + \vec{\omega} \times \vec{\omega} \times \vec{\rho}_{AB}$)



a) $V.i$ and $0.j$

b) $2V.i$ and $\frac{V^2}{R}.j$

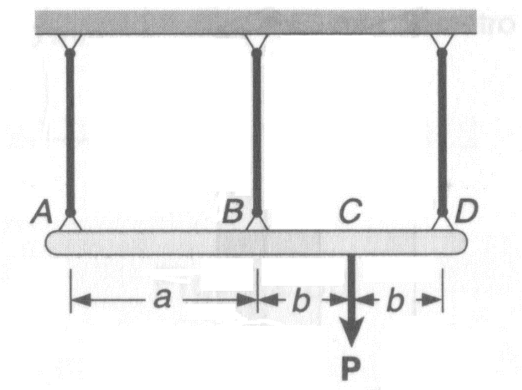
c) $V.i$ and $\frac{V^2}{R}.j$

d) $2V.i$ and $-\frac{V^2}{R}.j$

e) None of the other alternatives

Question 8

A horizontal rigid bar *ABCD* is supported by three identical cables (same geometrical and physical properties). These cables present linearly elastic behavior. Then, a force *P* is applied on point *C*, as it is shown in the following figure. The cables are equally spaced by distance *a*, and *b* represents half of *a* ($a = 2.b$). Assuming that the bar *ABCD* remains at static equilibrium after the application of force *P*, compute the magnitudes of the tensile forces acting on the three cables. Mark the alternative that indicates the more adequate values of the tensile forces on cables connected to joints *A*, *B*, and *D*, respectively.



(a) None of the other alternatives.

(b) 0.2.*P*, 0.4.*P*, and 0.4.*P*

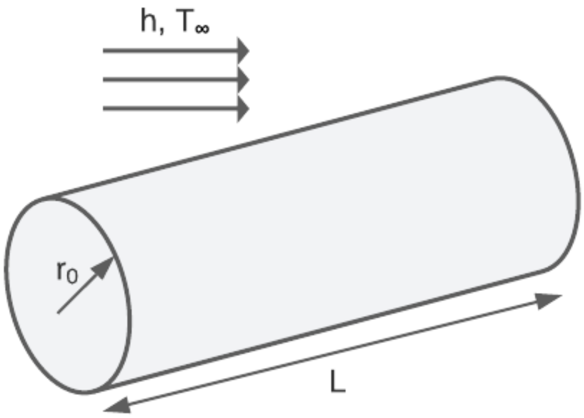
(c) 0.1.*P*, 0.3.*P*, and 0.7.*P*

(d) 0.33.*P*, 0.33.*P*, and 0.33.*P*

(e) 0.1.*P*, 0.3.*P*, and 0.6.*P*

Question 9

Radioactive wastes are packed in a long, thin-walled cylindrical container, with lenght L.



The wastes generate thermal energy nonuniformly according to the relation $\dot{q} = \dot{q}_0\left[1 - \left(\frac{r}{r_0}\right)^2\right]$, where $\dot{q}$ is the local rate of energy generation per unit volume, $\dot{q}_0$ is a constant, and r_0 is the radius of the container. Steady-state conditions are maintained by submerging the container in a liquid that is at T_∞ and provides uniform convection coefficient h. Which expression represents superficial temperature T_s of the container wall?

a) $T_s = T_\infty$.

b) $T_s = T_\infty + \frac{\dot{q}_0 r_0}{2h}\left[1 - \left(\frac{r}{r_0}\right)^2\right]$.

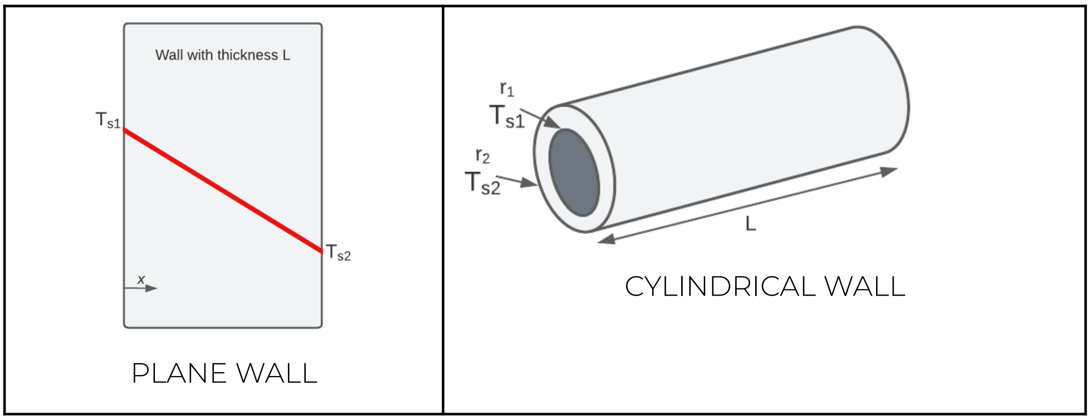
c) $T_s = \frac{\dot{q}_0 r_0}{2h}\left[1 - \left(\frac{r}{r_0}\right)^2\right] - T_\infty$.

d) $T_s = T_\infty + \frac{\dot{q}_0 r_0}{4h}$.

e) none of the other alternatives.

Question 10

Consider a one-dimensional, steady state solution to the heat equation with no generation, in a plane wall and in a cylindrical wall, as in the following figures:



The heat conduction expressions are summarized in the following table, where $\Delta T = T_{s1} - T_{s2}$ and A is the area.

		PLANE WALL	CYLINDRICAL WALL
A	Heat Equation	$\frac{d^2T}{dx^2} = 0$	$r\frac{d^2T}{dr^2} = 0$
B	Temperature distribution	$T_{s1} - \Delta T\left(\frac{x}{L}\right)$	$T_{s2} + \Delta T\left[\frac{\ln(r/r_2)}{\ln(r_1/r_2)}\right]$
C	Heat flux (q'')	$kA\frac{\Delta T}{L}$	$\frac{2\pi L k \Delta T}{\ln(r_2/r_1)}$
D	Heat rate (q)	$k\frac{\Delta T}{L}$	$\frac{1}{r}\frac{k\Delta T}{\ln(r_2/r_1)}$
E	Thermal resistance to conduction	$\frac{L}{kA}$	$\frac{\ln\left(\frac{r_2}{r_1}\right)}{2\pi L k}$

a) B, C and D are correct.

b) A and E are correct.

c) C and D are correct.

d) B and E are correct.

e) none of the other alternatives.

Question 11

FIA (International Automobile Federation) has established new rules for the next-generation Formula One power units from 2026. The federation recognized that the most powerful racing cars in the world still need to rely on internal combustion engines to achieve high performance in long races, but seeks to improve fuel efficiency and be more environmentally responsible in the next years. In this matter, F1 engines will run on 100% sustainable fuels instead of gasoline, and ethanol is one of the leading candidates to replace the fossil fuel option.

Source: F1™ - 7 things you need to know about the 2026 F1 engine regulations, August 2022. Available: https://www.formula1.com/

Choose one advantage of replacing gasoline with ethanol as a fuel for 2026 Formula One racing cars.

a) The lower octane rating of ethanol, compared to gasoline, allows higher maximum engine power and torque values to be achieved.
b) Ethanol's improved physicochemical properties allow for an increase in the volumetric compression ratio of high-performance engines, leading to consequent gains in thermal efficiency.
c) The greater ease of engine operation in cold-start and warm-up situations, due to ethanol's lower latent heat of vaporization.
d) The large availability of the alcohol-based fuel, due to the consolidation of its production and distribution on a global level.
e) The greater ease of engine operation in countries that present cold and rainy climates, due to ethanol's lower octane rating.

Question 12

The entropy change ΔS of a system is given by the expression below, in which Q is the heat exchanged between the system and its surroundings, T is the absolute temperature at the boundary of this heat exchange and ΔS_G is the entropy generation in the system caused by due to internal irreversibilities.

$\Delta S = \int(\delta Q/T) + \Delta S_G$

From this expression, a student drew the following conclusions about state transformations undergone by a system:

I. Every reversible and adiabatic transformation is isentropic.
II. Every isentropic transformation is reversible and adiabatic.
III. Every transformation with the addition of heat produces an entropy increase in the system.
IV. Every transformation with removal of heat produces entropy reduction of the system.

Which of these conclusions are CORRECT?

a) Only III and IV
b) Only I and II
c) Only I and III
d) All
e) None

Question 13

With regard to tool-condition monitoring systems applied to machining processes, it is not true to state that

a) direct measurement of tool wear requires that the cutting operation be stopped.

b) indirect tool-condition monitoring using acoustic emission is effective in precision machining.

c) in lower-cost computer numerical control machine tools, the cutting tool is generally replaced when its life expectancy is reached, irrespectively of the wear level.

d) direct tool-condition monitoring can be easily performed by the operator in modern computer numerical control machine tools.

e) transducers for indirect tool-condition monitoring are available in original machine tools or can be retrofitted on existing machines.

Question 14

An incompressible fluid of density ρ flows with velocity V, without elevation differences. From the static pressure at a point in this flow, it is possible to establish the following relationship for the stagnation pressure:

a) $p + \frac{1}{2}\rho V^2$
b) $\frac{1}{2}(p + \rho V^2)$
c) $\frac{p}{2} + \rho V^2$
d) $p + 2\rho V^2$
e) $p + \rho\left(\frac{V}{2}\right)^2$

Question 15

A pure substance is one that has its chemical composition invariable and homogeneous, regardless of its physical state, that is, it can exist in more than one phase, but the chemical composition is the same in all of them. Water, ammonia, carbon dioxide and some refrigerants such as R22 and R1234yf are examples of pure substances.

From this text, a student drew the following conclusions:

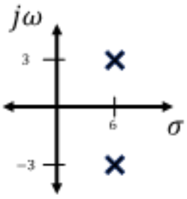
I. The physical state of a pure substance is defined by any two physical properties.
II. Dry air behaves like a pure substance over a wide range of temperatures and pressures.
III. A mixture composed of 22% R22 and 78% R1234yf by weight is a pure substance.
IV. The physical state of ammonia is always defined from its temperature and enthalpy.

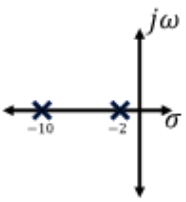
Which of these conclusions are CORRECT?

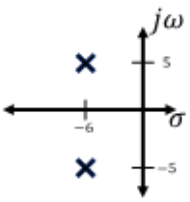
a) Only II and IV
b) Only I and IV
c) All
d) Only I and III
e) None

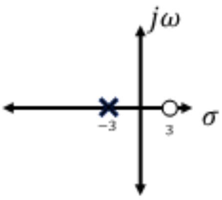
Question 16

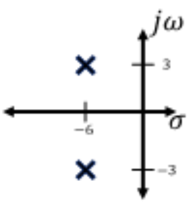
A customer requests from you a system that the step response should be as fast as possible and with as little overshoot as possible. You may select from among systems (A), (B), (C), (D) and (E) whose complex poles and zeros are shown, respectively.

a) 

b) 

c) 

d) 

e) 

Question 17

The control design process consists of seven main blocks organized into three groups as presented in Figure 1.

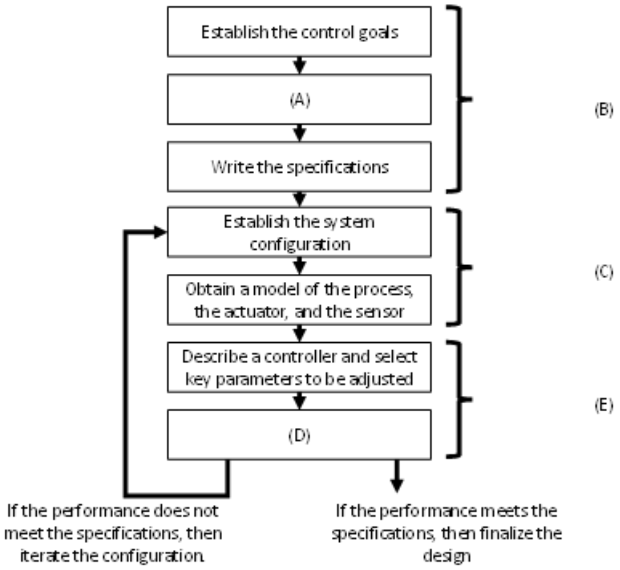


Figure 1

Please match the missing specs and groups in Figure 1

a)	A. Identify the variables to be controlled. B. Group 1. System definition and modeling. C. Group 2. Establishment of goals, variables to be controlled and specifications. D. Optimize the parameters and analyze the performance. E. Group 3. Control system design, simulation, and analysis.
b)	A. Optimize the parameters and analyze the performance. B. Group 1. Establishment of goals, variables to be controlled and specifications. C. Group 2. Control system design, simulation, and analysis. D. Identify the variables to be controlled. E. Group 3. System definition and modeling.
c)	A. Optimize the parameters and analyze the performance. B. Group 1. System definition and modeling. C. Group 2. Control system design, simulation, and analysis. D. Identify the variables to be controlled. E. Group 3. Establishment of goals, variables to be controlled and specifications.
d)	A. Identify the variables to be controlled B. Group 1. Establishment of goals, variables to be controlled and specifications. C. Group 2. System definition and modeling. D. Optimize the parameters and analyze the performance E. Group 3. Control system design, simulation, and analysis.
e)	A. Identify the variables to be controlled B. Group 1. Control system design, simulation, and analysis. C. Group 2. Establishment of goals, variables to be controlled and specifications. D. Optimize the parameters and analyze the performance. E. Group 3. System definition and modeling.

Question 18

Considering the plastic deformation of polycrystalline metals, it is true to state that:

a) Grain-boundary ledges are not effective sources of defects.
b) The grain boundary structure contains highly mobile grain-boundary dislocations that produce extensive slip.
c) The dislocations group together within the boundary do not form a grain-boundary ledge.
d) As the misorientation angle of the grain boundary increases, the ledge density decreases.
e) The crystal structure determines the number and type of slip systems, fixes the Burgers vector and determines the lattice friction stress, which sets the base strength level and temperature dependence on strength.

Question 19

Considering the mechanical forming processes of polycrystalline metals, it is true to state that:

a) Von Mises showed that for a crystal to undergo a general change in shape by slip requires the operation of four independent slip systems.
b) The characteristic structure of the cold-worked state is a cellular substructure in which high-density-dislocation tangles form cell walls. The development of a cell structure is less pronounced for low temperature and high strain-rate deformation and in materials with low stacking-fault energies, so that cross slip is difficult.
c) An arbitrary deformation state is specified by the six components of the strain tensor, but because of the requirement of volume constancy ($\Delta V = 0 = \boldsymbol{\varepsilon}_{11} + \boldsymbol{\varepsilon}_{22} + \boldsymbol{\varepsilon}_{33}$), there are only three independent strain components.
d) Although each grain tries to deform homogeneously in conformity with the deformation of the specimen as a whole, the constraints imposed by continuity cause little differences in the deformation between neighboring grains and within each grain.
e) Elimination of blowholes and porosity as well as decrease of chemical heterogeneity in cast ingot may not be conducted by hot forging or hot rolling in order to improve ductility and fracture toughness.

Question 20

For the system below, considering a unit step input, the steady-state error (e_{ss}) is:

a) $e_{ss} = \lim_{s \to 0} [\frac{R(s)}{1+G(s)}]$

b) $e_{ss} = \lim_{s \to 0} [\frac{s\,R(s)}{1-G(s)}]$

c) $e_{ss} = \lim_{s \to 0} [\frac{s\,R(s)}{1+G(s)}]$

d) $e_{ss} = \lim_{s \to 0} [\frac{G(s)}{1+G(s)}]$

e) $e_{ss} = \lim_{s \to 0} [\frac{G(s)}{1-G(s)}]$