ADMISSION TEST FOR Ph.D. CANDIDATES PPGMEC-UFMG 2019

TEST 1

Duration: 118 minutes

Question 1) (3 minutes) Compute the value of S :

$$S = \int_{e-1}^{e^2-1} \frac{5}{x+1} dx$$

Choose the right answer:

a) 2

b) $e^2 - e$

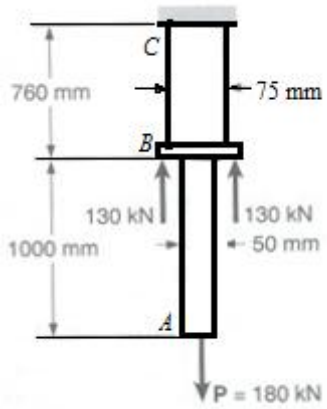
c) 4

d) 5

e) $\sqrt{2}$

Question 2) (5 minutes) Two solid circular cylinders are rigidly connected at B and are subjected to the forces depicted in the figure. The cylinder AB is manufactured of steel (E≈ 200 GPa) and the cylinder BC is manufactured of brass (E≈ 105 GPa). E represents the Young´s modulus. Compute the total elongation of the cylindrical bar ABC and the vertical displacement of the section B (Assume that downward direction is positive).

a) 0.63 mm e -0.23 mm.
b) 0.33mm e -0.13 mm.
c) 0.51 mm e -0.13 mm.
d) 0.51 mm e -0.23 mm.
e) 0.63 mm e -0.03 mm.



Question 3) (5 minutes) A rigid body with mass of 1kg slides at constant speed from the right to the left on a plain horizontal surface without friction, as it is shown in the figure. When the body reaches the point *B*, which marks the initial point of the movement along a circular path, the distance from the center of the circular path and the body

center of mass is 2m. The gravity acceleration is equal to 9.81m/s^2 and the motion is frictionless. What will be the body speed at point *B* such that the block can perform a complete turn along the circular path without losing contact?

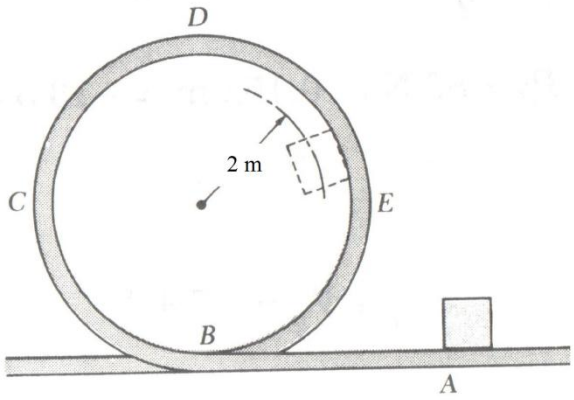
(a) About 4.43 m/s

(b) About 7.67 m/s

(c) About 9.91 m/s

(d) About de 8.86 m/s

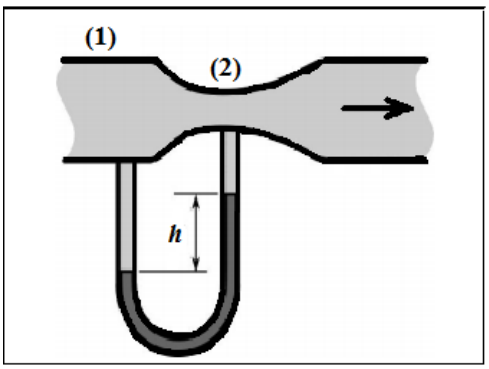
(e) None of the previous values



Question 4) (2 minutes) In relation to the convective heat transfer, choose the sentence that represents the correct statement about convection.

(a) In natural convection, the appopriate nondimensional parameter that describes this type of heat transport is the Grashof number, which can be considered an equivalent number to the Prandtl number for the forced convection.
(b) The Reynolds number is employed to estimate the natural convection film coefficient.
(c) The Nusselt number relates the wall heat conduction with the medium convection.
(d) In the natural convection, there is no motion of the fuid in contact with the heated surface.
(e) The thermal boundary layer occurs in heat transfer phenomena associated with the natural and forced convection.

Question 5) (8 minutes) A water flowmeter is built with a standard Venturi tube, as it is shown in the figure. The ratio of the upstream transverse cross sectional area to the Venturi cross sectional area is equal to 5. The Venturi is based on a U-tube manometer, in which the fluid has relative specific weight of 13.



Consider:

i) gravity acceleration, g, is 10 m/s^2;

ii) measured height, h, is 400mm;

iii) water specific weight, γ_{water}, is 10000 N/m^3;

iv) The upstream cross sectional area of the Venturi, A_1, is 100 cm^2;

v) Bernoulli equation: $\frac{P_A}{\gamma}+\frac{V_A^2}{2.g}+z_A=\frac{P_B}{\gamma}+\frac{V_B^2}{2.g}+z_B$

vi) Continuity equation: $\frac{\gamma}{g}.V_A.A_A=\frac{\gamma}{g}.V_B.A_B$.

What is the value of the water flowrate?

a) 1200 L/min

b) 433 L/min

c) 1800 L/min

d) 1541 L/min

e) 20000 L/min

Question 6) (2 minutes) With regard to manufacturing processes, the following statement is true:

a) casting provides higher production rate compared with forging

b) forging allows larger variability compared with milling in terms of component shape and dimensions

c) honing allows larger material removal rates compared with grinding

d) reaming ensures tighter dimensional and geometric tolerances compared with drilling

e) turning ensures tighter dimensional tolerances compared with grinding.

Question 7) (5 minutes) Obtain the values of α and β so that the vector V_1 is simultaneouly orthogonal to V_2 and V_3 (i, j and k are orthogonal unit vectors):

$$v_1=\alpha i+2j+\beta k \qquad v_2=3i+2j-3k \qquad v_3=i-4j+2k$$

Choose the correct values of α and β:

a) $\alpha=\frac{28}{9}$ $\beta=\frac{16}{9}$

b) $\alpha=\frac{16}{3}$ $\beta=\frac{28}{9}$

c) $\alpha=\frac{16}{9}$ $\beta=\frac{28}{3}$

d) $\alpha = \frac{28}{3}$ $\beta = \frac{16}{3}$

e) $\alpha = \frac{16}{9}$ $\beta = \frac{28}{9}$

Question 8) (4 minutes) Given the following matrix

$$M = \begin{bmatrix} 1 & 2 & 5 \\ 1 & 3 & 6 \\ 1 & 4 & 7 \end{bmatrix}$$

Compute the determinant of the matrix inverse M^{-1}.

Mark the value of this determinant from the options below:

a) 1/4

b) 1/6

c) 1

d) 4

e) none of the previous answers.

Question 9) (5 minutes) For the function

$$f(x) = \frac{1}{15}((x^2 + 1)^5 + 17)^{\frac{3}{2}}$$

What is the value of the first derivative of $f(x)$ at $x = 1$?

Mark the correct value of this derivative:

a) 100

b) 103

c) 112

d) 114

e) 116

Question 10) (3 minutes) The eigenvalues of the matrix *M*

$$M = \begin{bmatrix} 4 & -5 & 0 \\ \frac{1}{2} & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

must satisfy which one of the following polynomials:

a) $2\lambda^3 + 13\lambda = 10\lambda^2$

b) $2\lambda^3 - 13\lambda + 10 = 0$

c) $2\lambda^3 + 10\lambda = 13\lambda^2$

d) $\lambda^3 - 10\lambda^2 + 13 = 0$

e) $2\lambda^3 - 10\lambda + 13 = 0$

Question 11) (3 minutes) A circular solid bar made of aluminum (E = 77 GPa e α = 23.6x10^{-6}/^{0}C) with cross section diameter of 50 mm has undeformed length of 0.15 m. E represents the Young´s modulus. If this bar is subjected to a tensile force of 50 kN, the bar elongation (Δl) and the normal stress (σ) will be, respectively, equal to:

a) Δl = 0.055 mm and σ = 18.0 MPa

b) Δl = 0.50 mm and σ = 18.0 MPa

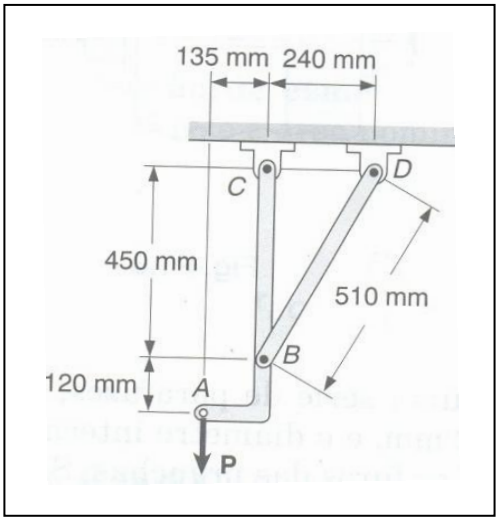
c) Δl = 0.050 mm and σ = 25.5 MPa

d) Δl = 0.55 mm and σ = 18.0 MPa

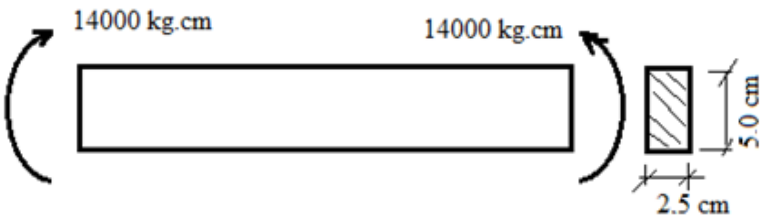
e) Δl = 0.55 mm and σ = 30.5 MPa

Question 12) (5 minutes) The connecting bar BD has uniform cross sectional area of 800 mm^2. Estimate the force **P**, such that the tensile stress on BD is 50 MPa.

a. 70.4 kN
b. 62.7 kN
c. 56.9 kN
d. 50.8 kN
e. 44.5 kN



Question 13) (4 minutes) A beam is subjected to a constant bending moment of 14,000 kg.cm, as it is shown in the figure. The dimensions of the rectangular cross section are b = 2.5 cm and h = 5.0 cm. The extreme values of the bending stresses are approximately equal to (σ_t = tensile stress and σ_c = compressive stress).



a) σ_t = 1344 kg/cm^2 e σ_c = -2688kg/cm^2

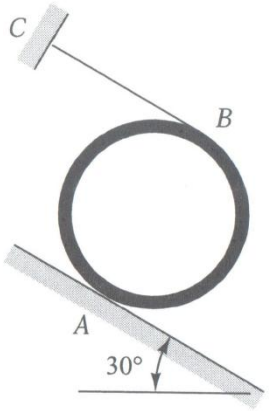
b) σ_t = 1344 kg/cm^2 e σ_c = -1344kg/cm^2

c) σ_t = 2688 kg/cm^2 e σ_c = -2688kg/cm^2

d) σ_t = 5373 kg/cm^2 e σ_c = -5373kg/cm^2

e) σ_t = 5373 kg/cm^2 e σ_c = -2688 kg/cm^2

Question 14) (5 minutes) A thin circular ring with weight of 600N and radius of 1.5m is at rest on a inclined plane. An inextensible rope *CB* impedes the rolling of the ring on the contact point *A*. What are the tensile force on the rope *CB* and the friction force on the contact point between the ring and the plane, respectively?



(a) 125N e 125N

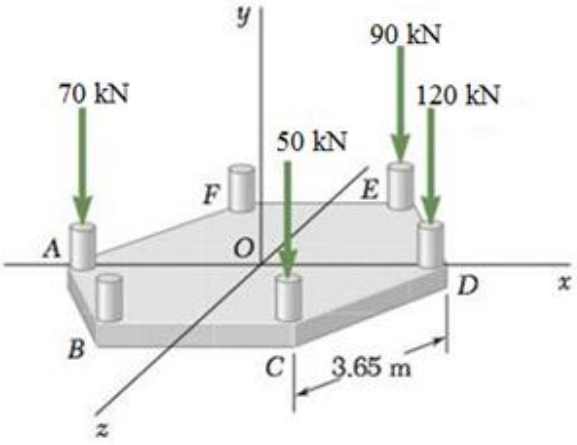
(b) 125N e 150N

(c) 150N e 125N

(d) 150N e 150N

(e) 300N e 519.6N

Question 15) (8 minutes) A hexagonal concrete base is designed to support the weight of six columns *A*, *B*, *C*, *D*, *E* e *F*. The hexagon side has length of 3.65m. The weights supported by four columns are shown in the figure. The origin of the reference frame *x*, *y* and *z* is located at point *O* and the directions of these orthogonal reference axes are indicated by the unit vectors ***i***, ***j*** e ***k***, respectively. What are the weights of columns *B* and *F*, respectively, such that the resultant force from the six column weights passes through the base center?



(a) 240 kN e 40 kN

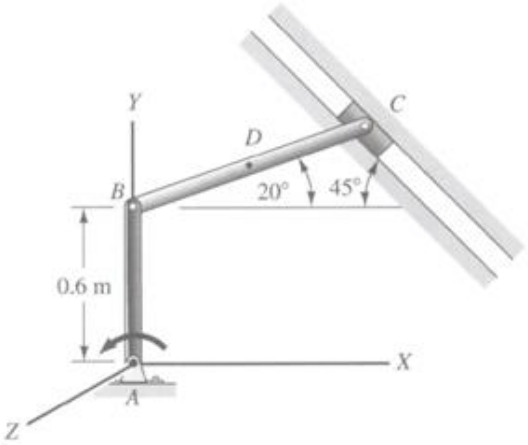
(b) 126.4 kN e 74 kN

(c) 438 kN e 126.4 kN

(d) 140.3 kN e 99.7 kN

(e) 165 kN e 90 kN

Question 16) (10 minutes) The rigid bar *AB* of a slider-crank mechanism rotates with angular speed of 5 rad/s in the counterclockwise direction. The rigid bar *BC* has length of 1 m. What are the magnitude and direction of the angular velocity of bar *BC*?



(a) 4.5 rad/s counterclockwise

(b) 4.5 rad/s clockwise

(c) 7.01 rad/s clockwise

(d) 7.01 rad/s counterclockwise

(e) None of the previous alternatives

Question 17) (4 minutes) The furnace wall of a metallurgical plant is manufactured with refractory bricks with thickness of 0.25m and thermal conductivity of 1.3W/mK. The internal furnace wall temperature is 1,327°C and the external wall temperature is 917°C.

The heat dissipated by a wall of 1.6m by 1.8m is approximately equal to

(a) 426W.

(b) 1,234W.

(c) 6,140W.

(d) 6,535W.

(e) 12,280W

Question 18) (8 minutes) The diameter of a solid circular shaft made of aluminum is measured by a micrometer at ambient temperature of 30°C, indicating the value of 20 mm for its diameter. This shaft must fit into a circular hole of a steel part with radial clearance of 1 mm, which must be kept.
Supposing that the mounted set will reach the temperature of 48ºC, what will be the correction needed in the shaft diameter to compensate the temperature rise?
Let´s assume that both the aluminum shaft and the steel part will be always at the same temperature.
(Data: α_{steel} = 11.5 μm.m^{-1}.K^{-1} e α_{Al} = 23.0 μm.m^{-1}.K^{-1}; 1μm = 10^{-6}m)

(a) – 8.3 x 10^{-3} mm.

(b) - 4.15 x 10^{-3} mm.

(c) - 13.39 x 10^{-2} mm.

(d) 66.9 x 10^{-3} mm.

(e) 13.93 x 10^{-2} mm.

Question 19) (3 minutes) A vertical U-tube manometer with mercury, which has both ends open to atmosphere, is accelerated in the horizontal direction, as it is shown in the figure. The acceleration causes a height difference of 125 mm in the U-tube from the original position at rest. The cross-section area of the tube is 12.57 mm^2 and the mercury mass density is 13600 kg/m^3. The magnitude of the gravity acceleration is considered equal to 10 m/s^2. Find the value of the horizontal acceleration.

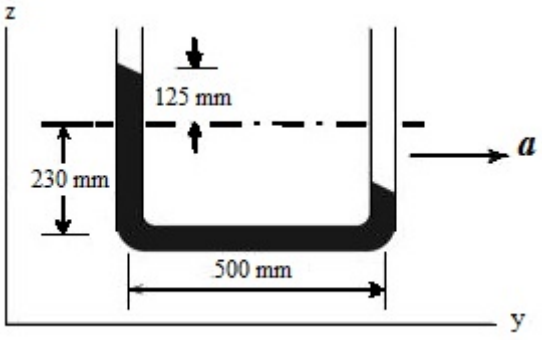
(a) The U-tube horizontal acceleration is 5 m/s^2.

(b) The U-tube horizontal acceleration is 8 m/s^2.

(c) The U-tube horizontal acceleration is 7 m/s^2.

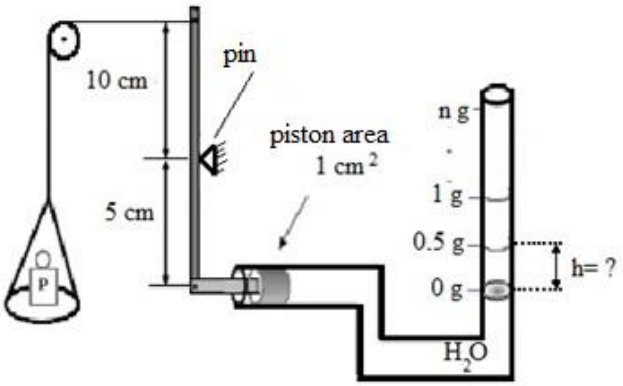
(d) The U-tube horizontal acceleration is 10 m/s^2.

(e) The U-tube horizontal acceleration is 15 m/s^2.



Question 20) (5 minutes) A scientist was trying unsucessfully to obtain a chemical component to produce a medicine. After some attempts, the scientist figured out that the problem was in the weighing balance employed in the apparatus. The replacement of the weighing balance would cause a long and unexpected delay in the experiments. Then, the scientist developed a very simple weighing-machine using available components in the laboratory, with interval scale of 0.5 g. The figure shows the device developed by the scientist.

What must be the value of h, in cm, to adjust the the tube measuring graduation?



Data: the weighing-machine uses water with mass density of 1 g/cm^3 and the gravity acceleration is equal to 10 m/s^2.

a) 0.25 cm

b) 0.5 cm

c) 1 cm

d) 1.5 cm

e) 5 cm

Question 21) (8 minutes) A car was fueled with 40 liters of gasoline (relative specific weight equal to δ=0.74), and the car tank has a base area of 0.4 m^2. However, the fuel employed to fill the tank was adulterated with a portion of solvent (δ=0.94). In order to estimate the amount of solvent, a manometer mounted at bottom of the car tank was used to measure the pressure of 0.008 kgf/cm^2. What was the volume of solvent found in the tank?

a) 10 L

b) 28 L

c) 8 L

d) 12 L

e) 20 L

Question 22) (2 minutes) Cutting tools are always prone to wear which will lead to their failure, irrespectively of their hardness and wear resistance.

Assess the following statements.

I. Oxidation and abrasion are thermally activated wear mechanisms

II. During intermittent cutting, tensile and compressive stresses act on the cutting tool alternately

III. The presence of coatings on cutting tools delays wear by diffusion

IV. Polycrystalline diamond cutting tools may fail due to wear by abrasion

The following statements are true

a) I and II

b) I and IV

c) III and IV

d) I, II e III

e) II, III e IV

Question 23) (5 minutes) A cutting tool employed in the turning operation presents the following geometry (ISO 3685:1993 standard): included angle (ε_r) of 80°, end cutting edge angle(χ'_r) of 5°, cutting edge inclination angle (λ_s) of -7°, clearance angle (α_o) of 10° and wedge angle (β_o) of 85°. The values of the rake angle (γ_o) and cutting edge angle (χ_r) are, respectively:

a) -5° and 95°

b) -2° and 90°

c) 73°and 92°

d) 23°and 67°

e) 85°and 5°

Question 24) (3 minutes) A solid circular prismatic shaft is made of steel. This shaft is subjected only to torsion. Choose the correct statement.

a) Any cross section will be subjected only to shear stresses.

b) No cross section will be subjected to tensile and/or compressive stresses.

c) A transverse plane (perpendicular to the torsion axis) is a principal plane.

d) A cross section inclined 45^{o} in relation to the torsion axis will be subjected to a biaxial stress state.

e) The shear stresses acting on the shaft transverse section (perpendicular to the torsion axis) are null.

Question 25) (3 minutes) A positive displacement pump supplies fluid to a hydraulic circuit at a volumetric flow rate of 0.002 m^3/s. If the circuit duct has cross-section area of 20 cm^2, the average fluid flow speed, in m/s, will be equal to

a) 0.1 m/s

b) 1.0 m/s

b) 2.0 m/s

c) 2.4 m/s

e) 4.9 m/s