UNIVERSITÀ DEGLI STUDI DI PAVIA

Facoltà di Ingegneria

ADMISSION TEST
INDUSTRIAL AUTOMATION ENGINEERING

September 26, 2016

The candidates are required to answer the following multiple choice test which includes 30 questions; for each question a single answer is due, to be selected from a set of three possibilities where at least one and only one is the correct solution. The candidate is required to answer correctly to at least 20 questions, in order to pass the test.
The time for the test is established in 2h 30 min.

THE USE OF MOBILE PHONES, LAPTOPS PC, IPAD AND OTHER DEVICES, TEXT AND NOTES OF ANY KIND, IS FORBIDDEN, **STUDENTS CAUGHT BREAKING ANY OF THESE RULES WILL BE EXPELLED**

Name and Surname: ______________________

Signature: ______________________

Questions

1 Electrical engineering

1. A single-phase induction motor has a rated voltage $V_n = 230$ V. The number 230 stands for

   ◯ the voltage average value

   ◯ the voltage peak (maximum) value

   √ **the voltage rms value**

2. Which protection devices are used to protect people from electric shock due to contact with under voltage metal parts?

   ◯ Distance relays

   √ **Residual current circuit breakers**

   ◯ Lightning rods

3. An $L - R$ load is fed from a PAS voltage of frequency f_1. What is the impedance of this load for a steady-state operation of the circuit?

   √ $Z = R + j2\pi f_1 L$

   ◯ $Z = L$

   ◯ It cannot be defined as the value of frequency in Hz is not given

4. Copper and aluminium:

   √ **have comparable resistivity of the order of** 10^{-8} Ω**m**

   ◯ the conductivity of aluminum is greater than that of copper

   ◯ the density of copper is less than that of aluminum

5. Let the field of magnetic induction due to a current-carrying straight conductor be considered. Which of the following statements holds?

   ◯ the induction value is directly proportional to the distance from the conductor

   √ **the field lines exhibit a circular shape and are located in planes orthogonal to the conductor**

   ◯ the field lines are parallel to the conductor

6. The magnetic flux linked with a current-carrying winding composed of N series-connected turns:

   ◯ is inversely proportional to N

   √ **is directly proportional to** N

   ◯ is directly proportional to N^2

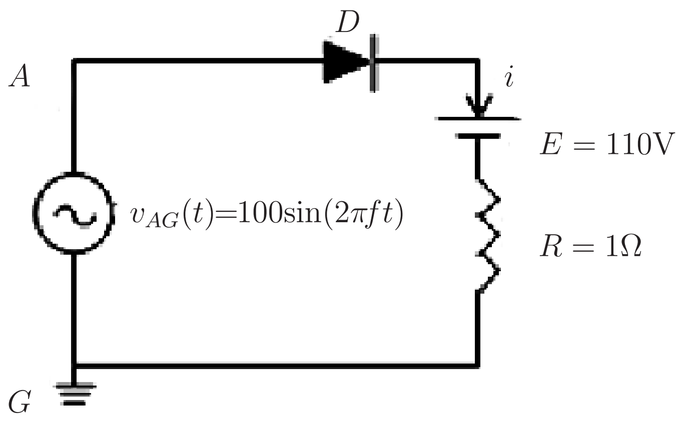

Figure 1

7. What is the steady-state value of current i in the circuit shown in figure 1 (the diode voltage drop is neglected)?
   - ○ $i = \dfrac{v - E}{R}$
   - √ $i = 0$
   - ○ $i = \dfrac{E - v}{R}$

8. Let a linear electrical two-terminal element be considered; the Thèvenin theorem holds that the voltage across the terminals is defined as:
   - √ **the no-load voltage**
   - ○ the voltage value when the current carried by the element is equal to the nominal current
   - ○ the short-circuit voltage

9. Let V be the voltage feeding a resistor of R ohm and P the Joule power loss when a current of I ampere flows through the resistor. If the current increases by 50%:
   - ○ V and P increase by 50%
   - √ V **increases by of** 1.5 **and** P **increases by a factor of** 2.25
   - ○ V and P become four times the original values

10. The magnetic permeability of a ferromagnetic material is
    - ○ Less than the air permeability
    - ○ A pure number
    - √ **Measured in [H/m]**

2 Mechanical engineering

1. Calculate the x coordinate of the center of mass of a body made up of a homogeneous beam with mass m and length l and a lumped mass equal to M placed at the distance $3L/4$ from the origin of the coordinate system (as shown in the figure)

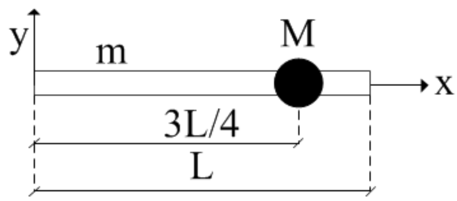

Figure 2

○ $x_g = \dfrac{m\dfrac{L}{2} + M\dfrac{3L}{4}}{mM}$

○ $x_g = \dfrac{mM\dfrac{3L^2}{8}}{m+M}$

√ $x_g = \dfrac{m\dfrac{L}{2} + M\dfrac{3L}{4}}{m+M}$

2. Given two vectors a and b with: $|\vec{a}| = 4, |\vec{b}| = 3$ and knowing the angle $\theta = 180°$ between them, the module of the vector $\vec{c} = \vec{a} + \vec{b}$ is:

√ 1

○ -1

○ 7

3. An electrical motor is required to lift a load with a mass $m = 1000$ kg at the speed of 1 m/s. Its rotational speed is 1480 rpm. Calculate the required torque.

○ 6165 Nm

○ 100 Nm

√ 61.65 **Nm**

4. An elevator is required to lift a mass of 600 kg at a rated speed of 0.8 m/s. Assuming the efficiency of the mechanical transmission system equal to 0.8, choose the minimum value of the power of the electric motor needed to lift the load:

○ 600 W

○ 12 kW

√ 5.89 **kW**

5. The angular velocity of a disc having a radius equal to 1m, that rotates without drag, is 10 rpm. The velocity module at its centre is:

   ◯ 10 m/s

   √ 1.047 **m/s**

   ◯ 0.167 m/s

6. For the motion act shown in the figure, where is the centre of instantaneous rotation (CIR) of the AB link?

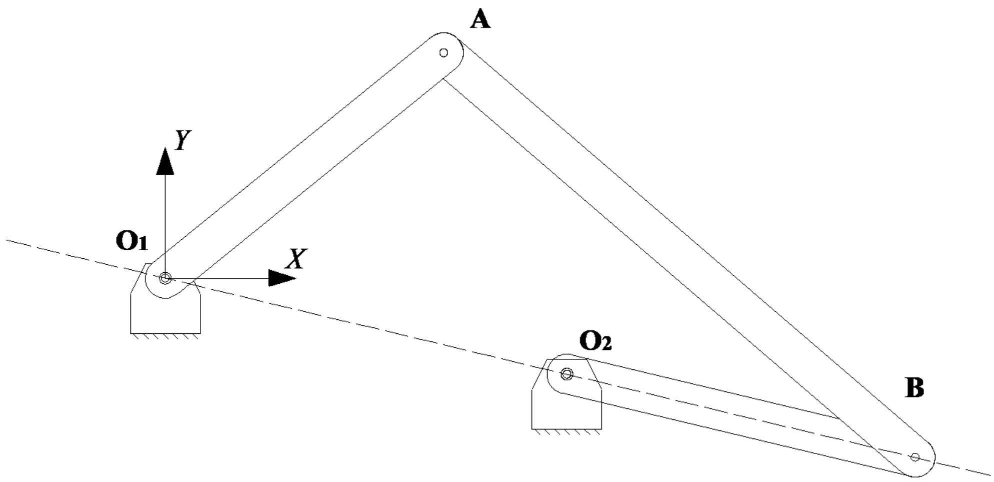

Figure 3

   ◯ A

   ◯ O_2

   √ O_1

7. Assuming that J_G is the moment of inertia referred to an axis passing through the centre of mass of a rigid body with mass M, and J_p is the moment of inertia referred to another axis parallel to the previous one passing through a point P. Knowing that the distance from the two axes is d, which of the following relationship is the correct one?

   √ $J_p = J_G + Md^2$

   ◯ $J_p < J_G$

   ◯ $J_p = Md^2$

8. Given a system of rigid bodies at 1 dof, between the power of the inertia forces W_i and the kinetic energy E_c the following relationship is valid:

   ○ $E_c = W_i$

   √ $\frac{\mathbf{d}E_c}{\mathbf{d}t} = -W_i$

   ○ $\frac{\mathrm{d}W_i}{\mathrm{d}t} = -E_c$

9. Find the polar coordinates of a point that in the Cartesian coordinates is placed in $(4\frac{\sqrt{3}}{2}, 2)$:

   √ $\rho = 4$, $\alpha = \frac{\pi}{6}$

   ○ $\rho = 2\sqrt{3}$, $\alpha = \frac{\pi}{6}$

   ○ $\rho = 2$, $\alpha = \frac{7\pi}{6}$

10. A known geometrical disc rotates without dragging over an horizontal guide which moves with an assigned velocity equal to v_2. All forces applied to the disk are known, including the velocity v of its center and its angular velocity ω. The power dissipated by the disk due to such rolling is:

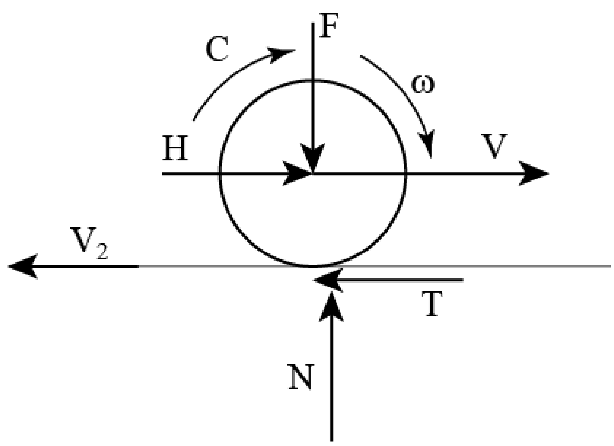

Figure 4

   ○ $Tf_v v$

   ○ $Nu\omega$

   √ $-Nu\omega$

3 Automatica

1. The following linear time-invariant systems:

$$\Sigma_1 : \begin{cases} \dot{x}_1 = -5x_1 - 7x_2 \\ \dot{x}_2 = -2x_2 \end{cases}, \qquad \Sigma_2 : \begin{cases} \dot{x}_1 = 3x_1 \\ \dot{x}_2 = 2x_2 \end{cases}$$

   ○ are both asymptotically stable

   ○ are both unstable

   √ **Σ_1 is asymptotically stable and Σ_2 is unstable**

2. The nonlinear system

$$\begin{aligned} \dot{x}_1 &= x_2 \\ \dot{x}_2 &= -x_1 + x_2(1 - x_1^2 + u) \end{aligned}$$

   associated with $\bar{u} = 1$, has only

   √ **one equilibrium state**

   ○ two equilibrium states

   ○ three equilibrium states

3. For the nonlinear system at the previous point, let $\dot{\delta x} = A\delta x + B\delta u$ be the linearization about the equilibrium state $\bar{x}^T = \begin{bmatrix} \bar{x}_1 & \bar{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 0 \end{bmatrix}$ and the equilibrium input $\bar{u} = 1$. One has

   ○ $A = \begin{bmatrix} 0 & 1 \\ 1 & 2 \end{bmatrix}$

   √ $A = \begin{bmatrix} 0 & 1 \\ -1 & 2 \end{bmatrix}$

   ○ $A = \begin{bmatrix} -1 & 1 \\ 2 & 0 \end{bmatrix}$

4. The transfer function $G(s)$ of the linear system

$$\begin{aligned} \dot{x}_1 &= x_1 \\ \dot{x}_2 &= x_1 + 2x_2 + u \\ y &= -3x_1 + 3x_2 \end{aligned}$$

   is

   ○ $G(s) = -\dfrac{4}{s+1}$

   √ $G(s) = \dfrac{3}{s-2}$

   ○ $G(s) = \dfrac{2}{s+1}$

5. The step response of $G(s) = \dfrac{5(s-1)}{\left(\frac{s}{2}+1\right)\left(\frac{s}{4}+1\right)}$

   ◯ has an overshoot

   ◯ goes to 5 for $t \to +\infty$

   √ **takes both positive and negative values**

6. The transfer function $G(s) = \dfrac{s-1}{2s^2 - 2s + 1}$

   √ **is unstable**

   ◯ is minimum phase

   ◯ has relative degree equal to two

7. Consider the block diagram where $R_1(s) = 2$, $R_2(s) = \dfrac{1}{s}$ and $G(s) = \dfrac{1}{s}$, the transfer

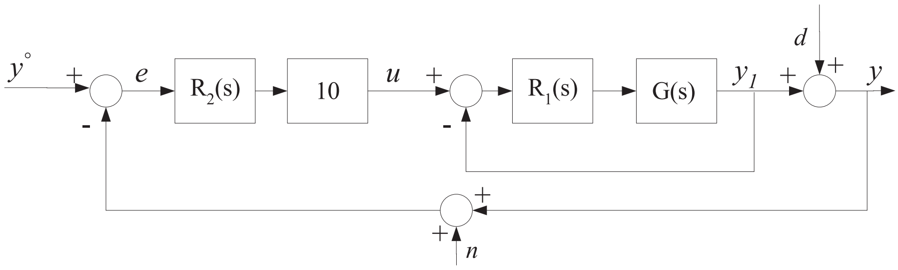

Figure 5

function $\tilde{G}(s)$ with input d and output y is

   ◯ $\tilde{G}(s) = 1$

   √ $\tilde{G}(s) = \dfrac{s^2 + 2s}{s^2 + 2s + 20}$

   ◯ $\tilde{G}(s) = \dfrac{s^2}{s^2 + 20}$

8. Consider the block diagram in figure 6 where $R(s) = 10$ and $G(s) = \dfrac{\left(\frac{s}{10}+1\right)}{\left(\frac{s}{100}+1\right)^2}$. Then

   √ **the approximate bandwidth of the closed-loop system is** $10000\ rad/s$

   ◯ the approximate bandwidth of the closed-loop system is $100\ rad/s$

   ◯ the closed-loop system is unstable

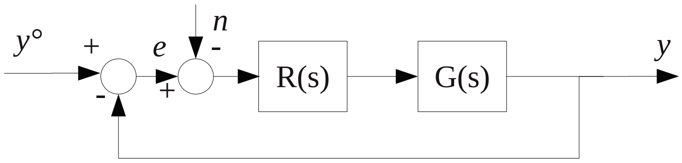

Figure 6

9. Consider the block diagram in figure 6 and assume $R(s) = 10$, $G(s) = \dfrac{10}{s+1}$. Knowing that the closed-loop system is asymptotically stable, consider how much a sinusoidal signal $n(t)$ is attenuated, asymptotically, on the output $y(t)$. One has that

   √ $n(t) = \sin(10000t)$ **is attenuated at least** 10 **times**

   ○ $n(t) = \sin(t)$ is attenuated at least 10 times

   ○ $n(t) = \sin(0.01t)$ is attenuated at least 10 times

10. The observability property of a LTI system $\dot{x} = Ax + Bu$, $y = Cx + Du$ depends only from the metrics

    √ A, C

    ○ A, B

    ○ B, C