KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechatronics Engineering
B. Sc. Engineering 2nd Year 1st Term Examination, 2020
EEE 2131
(Electronics)

Time: 1 Hour 30 Minutes   Total Marks: 120

N.B.: i) Answer any TWO questions from each section in separate scripts.
      ii) Figures in the right margin indicate full marks.
      iii) Assume reasonable data if any missing.

SECTION-A

1(a) What is meant by intrinsic and extrinsic semiconductor? Describe the importance of semiconductor doping.   08

1(b) Derive the following mass action law from the electron and hole concentration.   12

$$n_p = N_c N_v \, exp \left(\frac{-E_g}{kT} \right);$$ where the symbols have their usual meanings.

1(c) An n-type Si wafer has been doped uniformly with 10^{16} antimony (Sb) atoms cm^{-3}. Calculate the position of the Fermi energy with respect to the Fermi energy E_{Fi} in intrinsic Si. (Assume that T= 300 K, kT= 0.0259 eV and $n_i= 1\times10^{10}$ cm^{-3} for intrinsic Si)   10

2(a) What is rectification? Design a full-wave rectifier and half wave rectifier circuit using rectifier diode.   12

2(b) For a p-n junction, derive the following expression of the built-in potential barrier.   10

$$V_{bi} = V_t \, ln \, \frac{N_a N_d}{n_i^2};$$ where the symbols have their usual meanings.

2(c) Calculate the space charge width and electric field in a p-n junction for zero bias. Consider a Si p-n junction at T= 300 K with doping concentration of $N_a= 10^{16}$ cm^{-3} and $N_d = 10^{15}$ cm^{-3}, built-in potential barrier $V_{bi} = 0.635$ V, space charge width in n-region $X_n = 0.8644$ μm and relative permittivity of Si $\epsilon_r= 11.7$.   08

3(a) Write short notes on i) Dynamic capacitance; ii) Transition capacitance; iii) Diffusion capacitance; iv) Dynamic resistance and v) Contact potential   15

3(b) What are the functions of filter in rectifier circuit? Explain clamping and clipping circuits. What are the applications of these circuits?   15

SECTION-B

4(a) How depletion layer is formed in p-n junction? Draw the characteristic curve of p-n junction and identify each region.   15

4(b) Why do we need transistor biasing? Classify biasing method. For the following emitter-bias network, determine the following parameters: i) I_B, I_C and ii) V_{CE}, V_C, V_{BC} 15
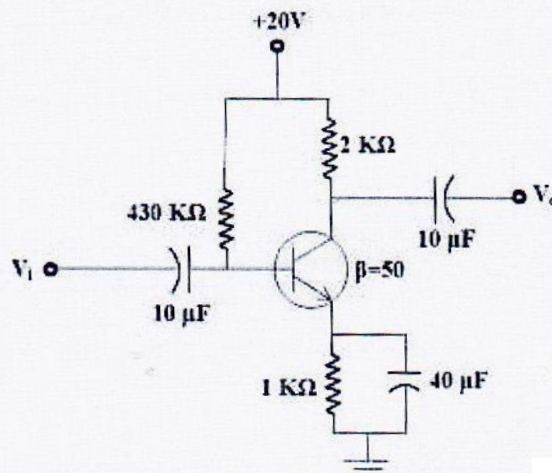
5(a)   Explain the operation of a n-channel D-MOSFET when i) V_{GS} = '−ve' V; ii) V_{GS} = '0' V and iii) V_{GS} = '+ve' V.

5(b)   Define threshold voltage. How MOSFET can be used as switch?   08

5(c)   Briefly explain operation of JFET and its characteristics curve.   10

6(a)   Explain shortly the following terms: i) Op-amp; ii) Offset null; iii) Filters; iv) Oscillators   15
       and v) Multivibrators

6(c)   Write down the application of op-amp. Design a current-controlled current source circuit   15
       using op-amp.

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechatronics Engineering
B.Sc. Engineering 2nd Year 1st Term Examination, 2020
Hum 2131
(Engineering Economics and Accounting)

Time: 1 hr. 30 min   Total Marks: 120

N.B.: i) Answer any TWO questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION-A

1(a) Why is "What to Produce" a problem in every economy? How does the price   15
mechanism solve this problem in a command economy?

1(b) What determines the quantity of a good that buyers demand?   15

2(a) Define price elasticity of demand. Is the price elasticity for white bread greater than   10
the price elasticity for bread in general? Why?

2(b) The "Karim Brothers" is a publisher of romance novels. The corporation hired an   20
economist to determine the demand for its product. After months of hard work the
economist informed the company that the demand for the firm's novel is given by
the following equation:

$$Q_x = 12000 - 5000P_x + 5I + 500P_c$$

Where,
Q_x is the demand for Karim Brothers' novels.
P_x is the price charged for Karim's novel.
I is the income per-capita.
P_c is the price from competing publisher.
Assume the initial value of P_x, I and P_c are $6, $1200 and $7 respectively. Using
the above information the manager wanted to determine-
   i.   What effect a price increased would have on total revenues.
   ii.   Evaluate how sale of the novel would change during a period of rising
         incomes.
   iii. Assess the probable impact if competing publishers would raise their prices.

3(a) How does a firm in a perfectly competitive market find the best level of output?   15

3(b) What is meant by a "competitive firm"? Under what conditions will a firm exit a   15
market? Explain.

SECTION-B

4(a) Define accounting. Why accounting is called the language of business?   15

4(b) Who are the users of accounting information? Explain.   15

5(a) Define transactions. What are the forms of transaction?   10

5(b) John started a delivery service in January, 2020 and following transactions   20
occurred:

January 1: John invented cash tk. 50,000 and furniture of tk. 30,000 to start the
business.

Jan 5: Purchased an equipment for tk. 20,000. Cash of tk. 12,000 was paid and a
note was signed for remaining cost.

Jan 10: Revenue earned but not yet collected tk. 5,000.

Jan 18: Paid tk. 3,000 cash on balance owed for equipment purchased on Jan 5.

Jan 25: Cash received tk. 8,000 by delivering service.

Required: Record above transactions in journal.

6. The followings are the balances of Arnold company as on December 31, 2019:   30

Account Titles	Debit (tk.)	Credit (tk.)
Cash	17,500	
Accounts receivables	3,200	
Supplies	1,800	
Furniture	10,000	
Accounts payable		7,300
Unearned Revenue		1,900
Capital		27,600
Withdrawals	4,000	
Fees received		11,600
Salary expense	2,800	
Utilities expenses	7,600	
Rent expense	1,500	
Total	48,400	48,400

Adjustments:
i) Unused supplies during the year tk. 800
ii) Charge depreciation on furniture tk. 500
iii)Salary due but not paid tk. 700

Required:
(a) Prepare a statement of comprehensive income for the year ended December
31, 2019.
(b) Prepare Owner's equity statement.

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechatronics Engineering
B.Sc. Engineering 2nd Year 1st Term Examination, 2020

Math 2131
(Fourier Analysis and Laplace Transform)

Time: 1 hr. 30 min   Total Marks: 120

N.B.: i) Answer any TWO questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION-A

1(a) Define Z-transform. Write down the important property of the ROC for Z-transform. Determine the Z-transform of $\{f(k)\}$, where   15
$$f(k) = \begin{cases} 5^k, k < 0 \\ 3^k, k \geq 0 \end{cases}$$

1(b) Find the inverse Z-transform of $X(z) = \frac{z}{(z-1)(z^2+1)}$ using residue method.   15

2(a) Define causal and non-causal system with example. Using convolution property, find the signal of $X(z) = \frac{1}{(1-\frac{1}{2}z^{-1})(1+\frac{1}{4}z^{-1})}$ 15

2(b) Determine the particular solution of $\frac{d^2x}{dt^2} - 3\frac{dx}{dt} + 2x = 4e^{2t}$, $x(0) = -3$, $x'(0) = 5$ using the Laplace transform.   15

3(a) Define integral transform. Also find the kernel of Laplace transform. Find the inverse Laplace transform of $\frac{2s^2-4}{(s+1)(s-2)(s-3)}$ using Heaviside expansion formula.   15

3(b) Solve the partial differential equation $\frac{\partial^2 u}{\partial x^2} - \frac{\partial^2 u}{\partial t^2} = xt$ if $u = \frac{\partial u}{\partial t} = 0$ when $t = 0$ using Laplace transform.   15

SECTION-B

4(a) Define even and odd functions with examples. Find the Fourier trigonometry series expansion of the periodic function $f(x)$ of period 2π, where   17
$$f(x) = x^2, -\pi \leq x \leq \pi$$
And hence show that $\frac{1}{1^2} - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} + \cdots = \frac{\pi^2}{12}$

4(b) Using Fourier integral formula, show that $e^{-x}cosx = \frac{2}{\pi}\int_0^\infty \frac{(u^2+2)cosux}{(u^2+4)}du$ 13

5(a) Find the complex form of Fourier series of periodic function whose definition in one period is $f(x) = e^{-x}, -1 < x < 1$ 17

5(b) Show that if the time signals $x(t)$ and $u(t)$ have Fourier transforms $X(\omega)$ and   13
$U(\omega)$ respectively, and if $\frac{d^2x(t)}{dt^2} + 3\frac{dx(t)}{dt} + 7x(t) = 3\frac{du(t)}{dt} + 2u(t)$, then
$X(\omega) = G(\omega)U(\omega)$ for some $G(\omega)$.

6(a) Write down the assumption for the validity of Fourier series expansion. If   15
$f(t) = t^2, 0 < t < 1$; then find half range Fourier sine series.

6(b) Solve $\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2}$, $x > 0, t > 0$, subject to the conditions $u(0,t) = 0$,   15
$u(x,0) = \begin{cases} 1, & 0 < x < 1 \\ 0, & x \geq 0 \end{cases}$, $u(x,t)$ is bounded using Fourier transform.

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechatronics Engineering
B.Sc. Engineering 2nd Year 1st Term Examination, 2020
ME 2131
(Engineering Mechanics)
Time: 1 Hour 30 Minutes   Total Marks: 120

N.B.: i) Answer any TWO questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.

SECTION-A

1(a) Determine the required length of cord AC in figure so that the 8 kg lamp can be suspended   15
in the position shown. The undeformed length of spring AB is 0.4 m and the spring has a
stiffness of 300 N/m.
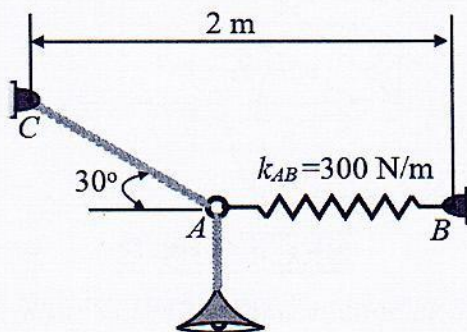
1(b) Two cables BG and BH are attached to frame ACD as shown in figure below. If the   15
tensions in the cable BG and BH are 540 N and 750 N respectively, determine the
components of the force exerted by cable BG and cable BH on the frame at B.
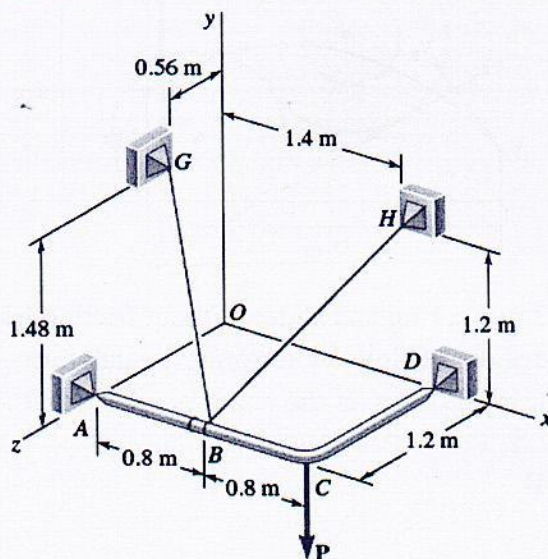
2(a) Consider a flat belt passing over a fixed cylindrical drum. Derive an expression for ratio   15
of tensions in flat belt.

2(b) Determine the location of the centroid of a parabolic spandrel as shown in figure below   15
by direct integration method.
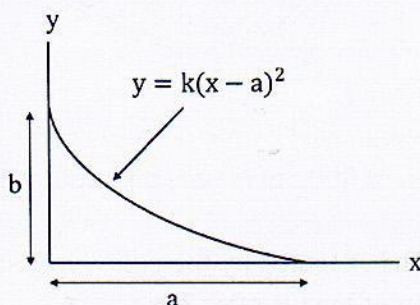
3(a) Determine by direct integration the mass moment of inertia and the radius of gyration   16
with respect to X-axis of the paraboloid shown in the figure below, assuming that it has

a uniform density and a mass m.
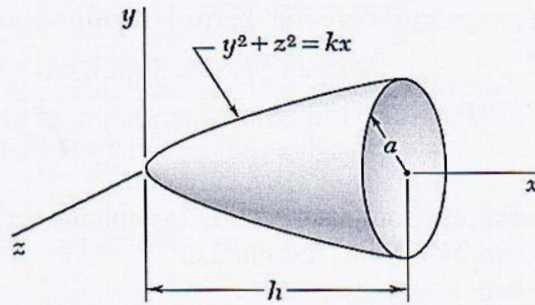
3(b) Determine the moment of inertia of the shaded area shown in the figure below with respect   14
to the Y-axis by direct integration method.
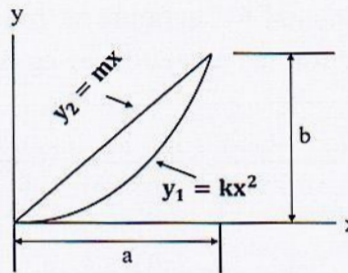
SECTION-B

4(a) A player throws a ball with an initial velocity of 15 ms^{-1} from a point A located 1.5 m above   14
the floor (figure shown below). Determine the angle α for which the ball will strike the wall
at point B.
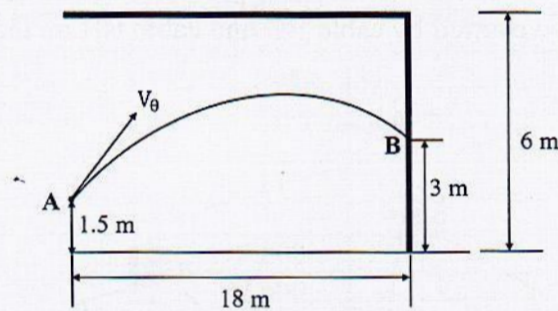
4(b) A 2 kg collar is attached to a spring and slides without friction in a vertical plane along the   16
curved rod ABC (figure shown below). The spring is undeformed when the collar is at C
and its stiffness constant is 600 N/m. If the collar is released at A with no initial velocity,
determine its velocity
i)   as it passes through B
ii) as it reaches C
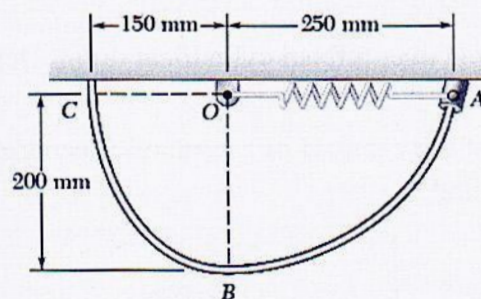
5(a) A pulley and two loads are connected by inextensible cords as shown in figure below. Load   16
A has a constant acceleration of 300 mm/s^2 and an initial velocity of 240 ms^{-1}, both directed
upward. Determine:
i)   The number of revolutions executed by the pulley in 3 sec
ii) The velocity and position of load B after 3 sec
iii) The acceleration of point D on the rim of the pulley at t=0
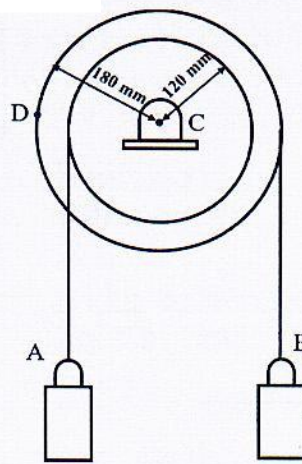
5(b) A drum of radius 90 mm is mounted on a cylinder of radius 120 mm as shown in figure   14
below. A cord is wound around the drum and is pulled in such a way that point D has a
velocity 90 mm/s and an acceleration of 450 mm/s^2 both directed to left. Assuming the
cylinder rolls without sliding, determine the acceleration of i) of point A and ii) of point C.
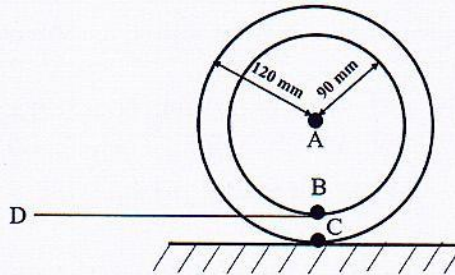
6(a) A homogenous cylinder C and a section of pipe P are in contact (figure shown below) when   15
they are released from rest. Knowing that both the cylinder and the pipe roll without slipping,
determine the clear distance between them after 3 sec.

$\beta = 15°$
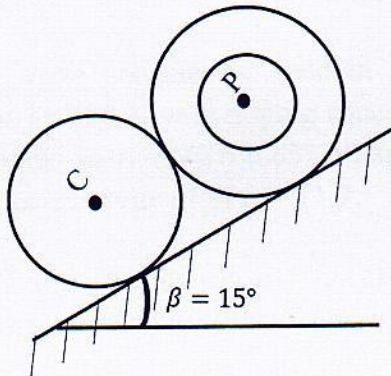
6(b) A sphere of weight W and radius r rolls without sliding inside a curved surface of radius R.   15
Knowing that the sphere is released from rest in the position shown in figure, derive an
expression for the linear velocity of sphere as it passes through B.
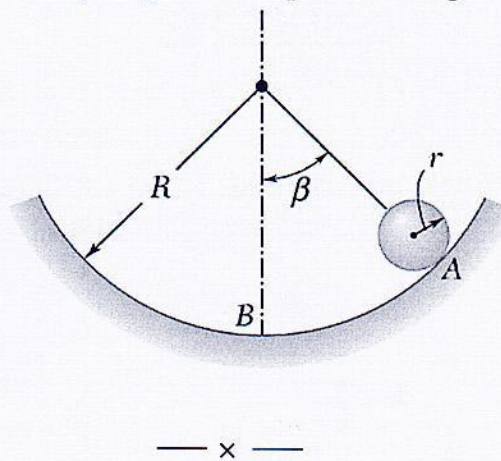
KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechatronics Engineering
B. Sc. Engineering 2nd Year 1st Term Examination, 2020
MTE 2105
(Sensors and Instrumentations)
Time: 1 Hour 30 Minutes   Total Marks: 120

N.B.: i) Answer any TWO questions from each section in separate scripts.
   ii) Figures in the right margin indicate full marks.
   iii) Assume reasonable data if any missing.

SECTION-A

1(a) What are the functional elements of a measurement system? A synchronous motor is rotating at a certain speed which needs to be measured with a light sensor. Discuss in brief how this sensor can measure angular speed of rotating motor shaft. **10**

1(b) Define piezoresistive effect. A single strain gauge having resistance of 120 Ω is mounted on a steel cantilever beam at a distance of 0.15 m from the free end. An unknown force F applied at the free end produces a deflection of 12.7 mm of the free end. The change in gauge resistance is found to be 0.152 Ω. The beam is 0.25 m long with a width of 20 mm and a depth of 3mm. The Young's modulus for steel is 200 GN/m^2. Calculate the gauge factor. **10**

1(c) The MTE department aims to construct a land mine detector. It's your role to assist them in choosing the right sensor for the job. Please write down the name of the sensor and a brief description of how it works. **10**

2(a) In the sensor and instrumentation lab, there are only two possible resistance values. As a result, your task is to construct a digital to analog converter using limited resources and determine its final output. **10**

2(b) Suggest the module that would be required to connect an analog sensor's output to a microcontroller. Draw the block diagram of the conversion process and explain each block. **10**

2(c) Draw and describe a basic sample and hold circuit. **10**

3(a) A linear resistance potentiometer (POT) is 50 mm long and is uniformly wound with a wire having resistance of 10 kΩ. Under normal conditions, the slider is at the center of the POT. Find the linear displacements when the resistance of the POT as measured by a Wheatstone bridge are respectively 3850 Ω and 7560 Ω. Are the two displacements in the same direction? **10**

3(b) Discuss the operation of an inductive sensor which is based upon variation of mutual inductance. **10**

3(c) Justify the statement, "Mobile touchscreen is an example of capacitive sensor". **10**

SECTION-B

4(a) Write short notes on i) VXI and ii) PXI 10

4(b) Write down five applications of accelerometer. A piezoelectric crystal having dimensions of 10
5 mm×5 mm×1.25 mm and a voltage sensitivity of 0.055 Vm/N is used for vibration
measurement. Calculate the force of seismic mass if the voltage developed is 100 volt.

4(c) A differential amplifier is used with a thermocouple sensor in the way shown in figure. What 10
values of R_1 and R_2 would give a circuit which has an output of 10 mV for a temperature
difference between the thermocouple junctions of 100°C with a copper-constantan
thermocouple if the thermocouple is assumed to have a constant sensitivity of 43 μV/°C.
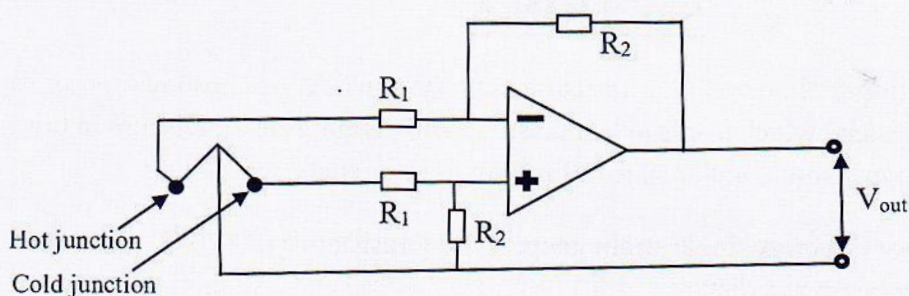
5(a) What is telemetry system and why it is required? Draw the block diagram of a single channel 10
telemetry system.

5(b) Draw the circuit diagram of an instrumentation amplifier. What are the key characteristics 10
of an instrumentation amplifier?

5(c) What is simplex and half-duplex data transmission? Point out some differences between 10
serial and parallel data transmission.

6(a) What kind of filter is it (shown in figure) if we take output across the resistor and why? 20
Calculate the cut-off frequency of this filter if L= 2 mH and R= 10 kΩ.
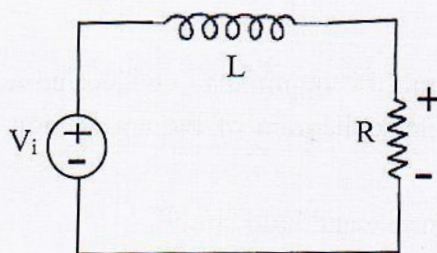
6(c) What is the resolution of an ADC with a word length of 12 bits and an analog signal input 10
range of 100 volt?

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