L-2/T-2/EEE **Date: 19/01/2021**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-II B.Sc. Engineering Examination 2018-19

Sub: **EEE 205** (Energy Conversion II)

Full Marks: 180 Time 2 Hours

The Figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

There are 3 page(s) in this question paper.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**

All the symbols have their usual meanings

Assume reasonable values for missing data.

1. (a) "Maximum power output of a dc motor under field current control is constant, while the maximum torque varies as the reciprocal of the motor's speed." (20)

Relate the above comment with the speed-torque and speed-power characteristics of a dc shunt motor under appropriate method of speed control.

(b) "A series motor gives more torque per ampere than any other dc motor." Explain the above comment. (10)

2. (a) Based on the expression for speed-torque characteristic of a dc shunt motor given below, discuss briefly the motor's speed control. (15)

$$\omega = \frac{V_T}{K\phi} - \frac{R_A}{(K\phi)^2}\tau_{\text{ind}}$$

(b) Explain briefly how armature reaction results in better speed regulation in a shunt dc motor, but may lead to runway condition under certain condition. (15)

3. (a) With reference to the 'double revolving-field theory' explain why torque due to reverse magnetic field in single-phase induction motor is very small near synchronous speed. (15)

(b) Make a comparison of the starting torque of a permanent split-capacitor motor to that of a capacitor-start motor of the same size? (15)

4. Discuss briefly all the factors that you would consider in design and operation of a solar PV power plant. (30)

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**

All the symbols have their usual meanings

Assume reasonable values for missing data.

5. (a) Draw the schematic diagram of a *Pilot Excitation System* for a synchronous generator. Explain how this scheme works. (12)

(b) A three-phase, 16 pole, 50 Hz star connected alternator has 144 slots and 10 conductors per slot. The flux per pole is $2{\cdot}48 \times 10^{-2}$ weber sinusoidally distributed. The coil pitch is 2 slots short of full pitch. Find (*i*) speed (*ii*) line to line emf. (18)

6. (a) Describe the method used for determination of X_d and X_q of a salient pole synchronous machine. Draw the necessary test setup prescribed for this method. (10)

(b) Construct the phasor diagram considering the *Two-Reaction Concept* of a salient pole synchronous machine. Hence derive the equation of power developed by that machine. (20)

7. (a) What is the necessity of parallel operation of alternators? What conditions are required to be satisfied before connecting an alternator to the infinite bus-bars? Draw the diagram for *Three Dark Lamps* method of synchronizing 3-phase alternators and explain the status of the lamps. (18)

(b) The governors of the two 50 MVA, 3-phase alternators operating in parallel, are set in such a way that the rise in speed from full-load to no-load is 2% in one machine and 3% in the other. The characteristics being straight lines in both cases. Each machine is fully loaded when the total load is 100 MW (unity pf). If in this condition the load is reduced to 75 MW what will be the load on each machine? (12)

8. (a) Show the effect of excitation change using the phasor diagrams of a synchronous motor. How these phasor diagrams (showing the effect of excitation change) can be related to under excitation, over excitation and unity p.f. region of a V-curve? (15)

(b) The excitation of a 3-phase synchronous motor connected in parallel with a load of 500 kW operating at 0·8 p.f. lagging is adjusted to improve the overall p.f. of the system to 0.9 lagging. If the mechanical load on the motor including losses is 125 kW, calculate the kVA input to the synchronous motor and its p.f (15)

L-2/T-2/EEE **Date: 16/01/2021**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-II B.Sc. Engineering Examination 2018-19

Sub: **EEE 207** (Electronic Circuits II)

Full Marks: 180 Time 2 Hours

The Figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

There are 6 pages in this question paper.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**

All the symbols have their usual meanings

Assume reasonable values for missing data.

1. (a) Write down the characteristics of ideal OP-AMP. Explain the application of an OP-AMP voltage follower with necessary diagram. (10)

(b) (i) Derive an expression for the voltage gain V_0/V_{in} of the circuit shown in Fig. for Q. 1(b). (ii) Evaluate your expression for R_1 = 1 kΩ and R_2 = 10 kΩ. (iii) Find the input resistance of this circuit. (iv) Find the output resistance. (20)

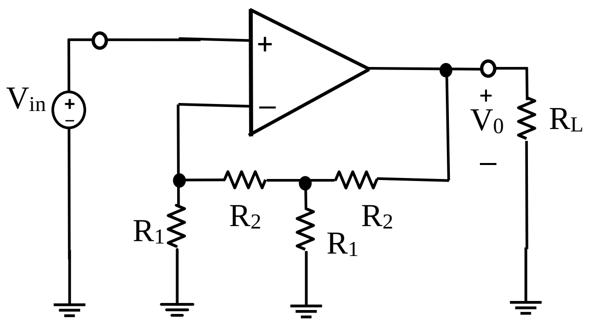


Fig. for Q.1 (b)

2. (a) Explain, with output voltage equation, what the circuit shown in Fig. for Q. 2(a) does. (15)

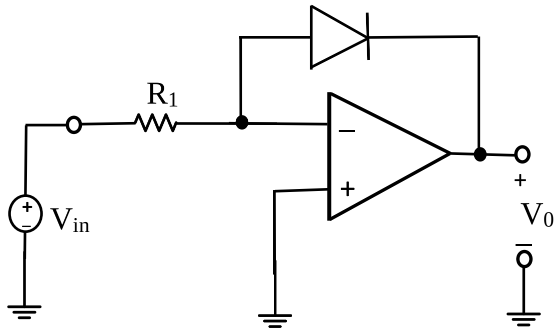


Fig. for Q. 2(a)

(b) Write down the basic difference between Comparator and Schmitt trigger circuits. Determine the output voltage waveform for the circuit shown in Fig. for Q. 2(b). Assume V_{in} is a bipolar triangular wave with a peak value of 5 V. (15)

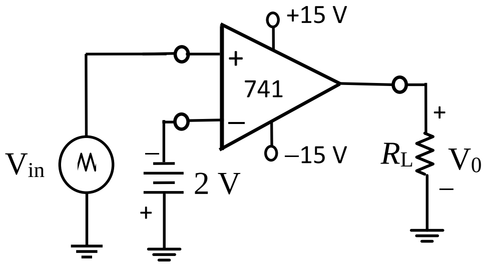


Fig. for Q. 2(b)

3. (a) Define slew rate in connection with OP-AMP. For the circuit shown in Fig. for Q. 3(a), determine whether the output voltage will be distorted or not. Given that the OP-AMP slew rate is 0.4V/µs. (12)

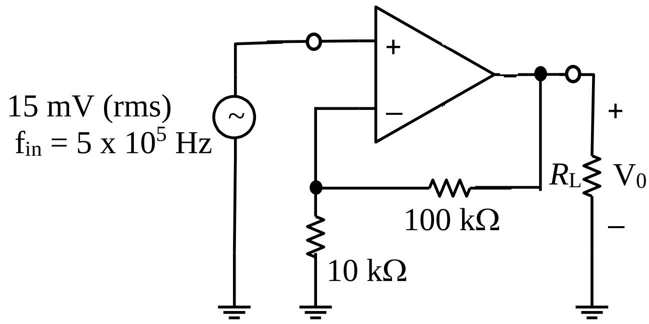


Fig. for Q. 3(a)

(b) The circuit diagram of an astable multivibrator using a 555 timer is shown in Fig. for Q. 3(b). Determine the frequency of the output and the duty cycle. What would be above values when diode is removed? (18)

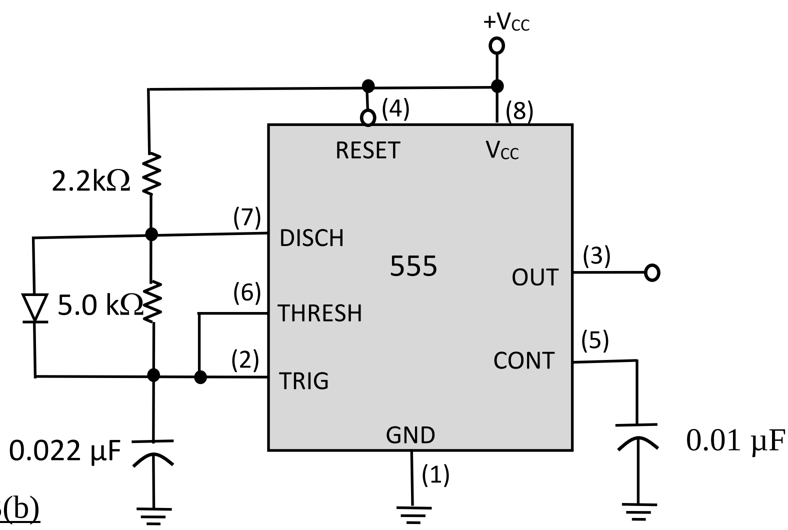


Fig. for Q. 3(b)

4 (a) Refer to Fig. for Q. 4(a), V_{i0} = 3 mV, I_{B-} = 0.4 μA and I_{B+} = 0.1 μA. (15)

(i) What is the best value of R if the source resistance is 10 Ω?

(ii) Calculate the individual error in the output voltage due to V_{i0} only and I_{os} only.

(iii) What is the actual value of output voltage when both input offset voltage and current are present along with V_s?

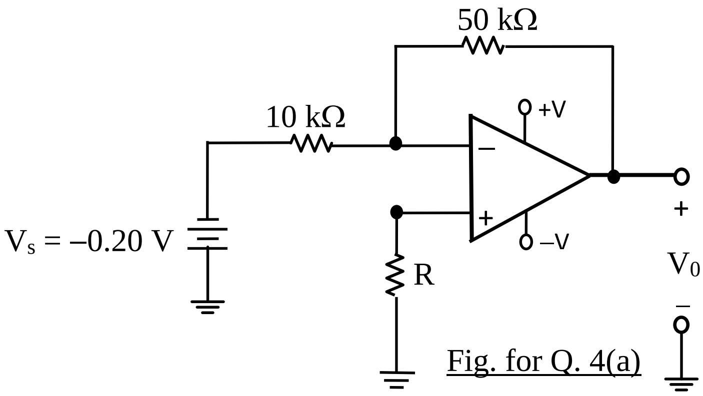


Fig. for Q. 4(a)

(b) A bandpass filter has a resonant frequency of 1000 Hz and a bandwidth of 2500 Hz. How would you convert this bandpass filter into a notch filter with the same resonant frequency and Q? Calculate f_{cL} and f_{cH} for the notch filter. (15)

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**

All the symbols have their usual meanings

Assume reasonable values for missing data.

5. (a) Draw the circuit diagram of the Colpitts Oscillator and explain how the Barkhausen criteria are satisfied in this circuit. Also, derive the expression for oscillating frequency and the conditions for sustainable oscillation. (15)

(b) For the oscillator circuit shown in Fig. for Q. 5(b) find oscillation frequency in Hz. (15)

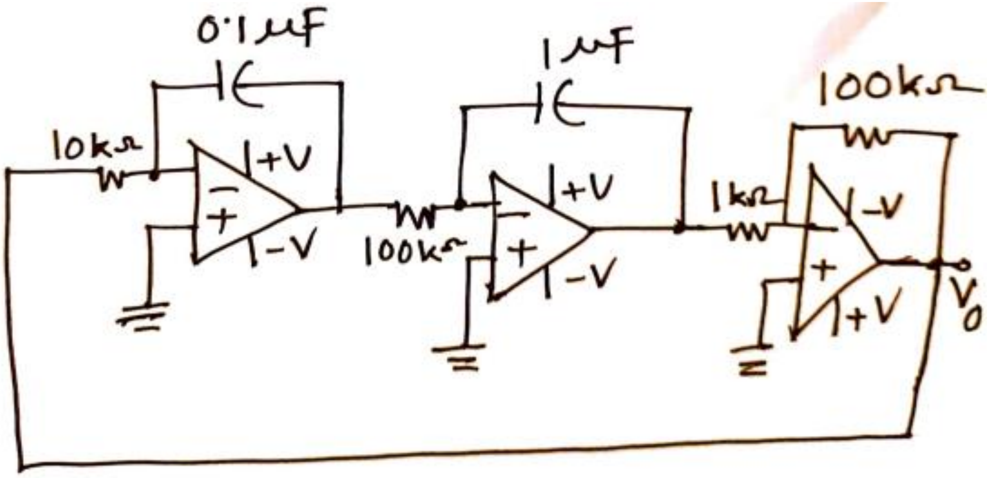


Fig. for Q. 5(b)

6. (a) Showing Q-point on load line, classify BJT power amplifier. Also mention how long the collector current remains nonzero for each class. (08)

(b) A Class A transformer coupled EF power amplifier must deliver an output of 0.5 W to an 8–Ω speaker. What transformer ratio is needed to provide this power if V_{CC} = 18 V? The transistor has V_{BE} = 0.7 V and β = 100. Assume zero resistance in the transformer. What transistor power rating is needed? (Consider undistorted output) (16)

(c) The low frequency response of an amplifier is characterized by the transfer function

$$F_L(s) = \frac{s\,(s+20)(s+500)}{(s+200)(s+400)(s+2500)}$$

Determine the lower 3-dB frequency approximately. Also, check whether the dominant pole approximation is valid or not. If valid, determine the lower 3-dB frequency using the dominant pole formulae too. (06)

7. (a) A particular amplifier has a voltage transfer function,

$$T(s) = \frac{10^5 s\,(s+10^3)}{(s+10^2)(s+10^4)}$$

Sketch a Bode plot for the magnitude response. From the plot, determine the approximate value of voltage gain in dB at ω =10^3 and 10^6 rad/sec. (15)

(b) Find the values for the coupling capacitors 'C_{C1}' and 'C_{C2}' and the bypass capacitor 'C_S' for the amplifier given in Fig. for Q. 7(b), so that the low frequency (15) response will be dominated by a pole at 100 Hz. Consider the nearest pole or zero will be at least a decade away.

Given that V_{DD} = 16 V, R = 100 kΩ, R_{G1} = 1.5 MΩ, R_{G2} = 0.5 MΩ, R_s = 3 kΩ, R_D = 5 kΩ, r_o = 1 MΩ, R_L = 10 kΩ and g_m= 5 mA/V.

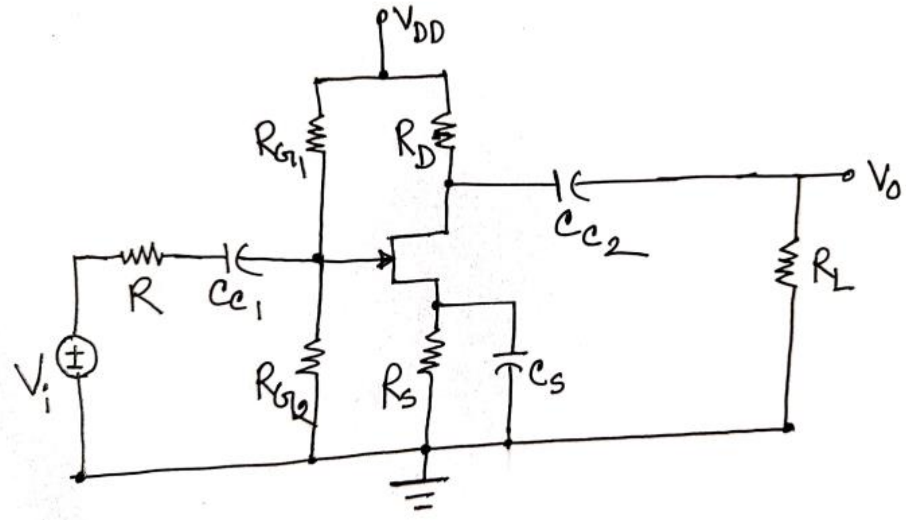


Fig. for Q. 7(b)

8. (a) Derive the expression for input resistance R_{if} and output resistance R_{of} of the given feedback amplifier as shown in Fig. for Q. 8(a) (15)

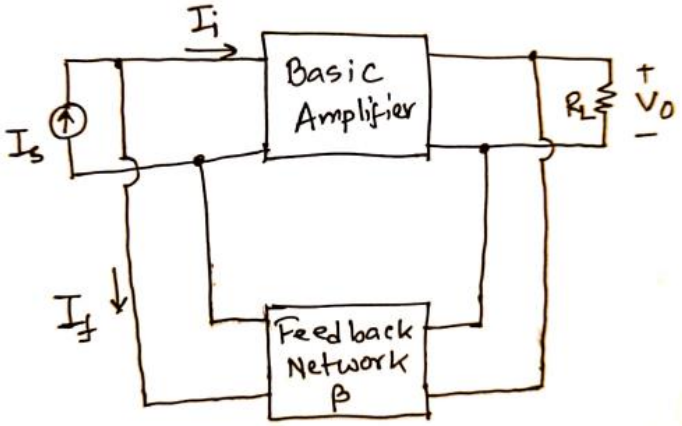


Fig. for Q. 8(a)

(b) Calculate the voltage gain A_{Vf} and input resistance R_{if} for the circuit shown in Fig. for Q 8(b). Given that h_{fe} = 120, h_{ie} = 1 kΩ, while h_{re} and h_{oe} are negligible. (15)

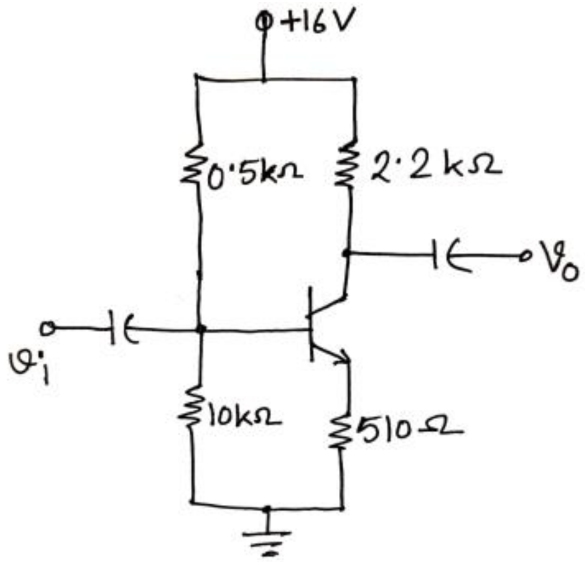


Fig. for Q. 8(b)

L-2/T-2/EEE **Date: 09/01/2021**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-II B.Sc. Engineering Examination 2018-2019

Sub: **EEE 209** (Engineering Electromagnetics)

Full Marks: 180 Time 2 Hours

The Figures in the right margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

There are 4 page(s) in this question paper.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**

All the symbols have their usual meanings

Assume reasonable values for missing data.

1. (a) An electron and a proton separated by a distance of 10^{-11} meter are symmetrically arranged along the z axis with z=0 as its bisecting plane. Determine the potential and E field at P(3,4,12). All distances are in meter. (10)

   (b) Two conducting planes of infinite extent in the z-direction are at $\phi=0^0$ and $\phi=60^0$. A point charge q is situated at $(2,\pi/6, 0)$ when both plates are at ground potential. Find the potential at a point $(5,\pi/6,0)$. (10)

   (c) An arc of radius 0.2 m lies in the z=0 plane and extends from $0\leq\phi\leq\pi/2$. It has a charge distribution of $600\sin 2\phi$ nC/m. Determine the E field at (i) a point (0,0,1) and (ii) the origin. (10)

2. (a) Define electric field intensity and electric scalar potential. Prove that $\bar{\mathbf{E}} = -\bar{\nabla}V$, $\oint \bar{\mathbf{E}}\cdot d\bar{\mathbf{l}} = 0$ and $\nabla^2 V = -\frac{\rho_v}{\varepsilon}$. The symbols have their usual meanings. (15)

   (b) A plane boundary of infinite extent in the z-direction passes through the points (4,0,0) and (0,3,0) as indicated in the Fig. 2(b). The electric field intensity in medium 1 (ε_r=2.5) is $\vec{E} = 25\hat{a}_x + 50\hat{a}_y + 25\hat{a}_z$ V/m. Determine the Electric field intensity in medium 2 (ε_r=5). (15)

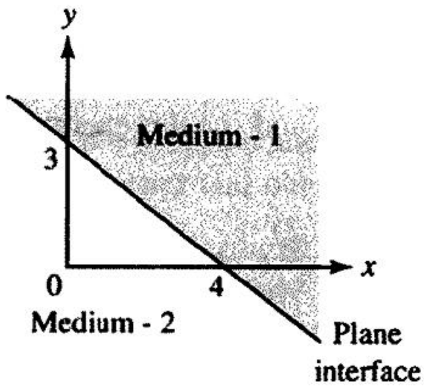


Fig. 2(b)

3. (a) A spherical capacitor has an inner conductor of radius a carrying charge Q and maintained at zero potential. If the outer conductor contracts from radius b to c under internal force, find the work performed by the electric field as a result of contraction. (15)

(b) A thin ring of radius 5 cm is placed on plane z=1 cm so that its center is at (0,0,1 cm), if the ring carries 50 mA along $\mathbf{a}_\phi$, find **H** at (0,0,-1 cm) and (0,0,10 cm). (15)

4 (a) Determine the magnetic flux through a rectangular loop (a×b) due to an infinitely long conductor carrying current I as shown in the Fig. 4(a). The loop and the straight conductors are separated by distance d. (15)

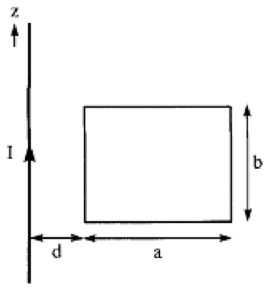


Fig. 4(a)

(b) A rectangular coil of area 10 cm^2 carrying a current of 50 A lies on the plane 2x+6y-3z=7 such that the magnetic moment of the coil is directed away from the origin. Calculate its magnetic moment. (15)

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**

All the symbols have their usual meanings.

Assume reasonable values for missing data.

5. (a) Derive the charge-current continuity equation and explain how this equation leads to Kirchhoff's current law. (10)

(b) The rectangular loop as shown in Fig. 5(b) is located in the *xy*-plane and moves away from the origin with velocity $\bar{\mathbf{u}} = \hat{\mathbf{y}}5$ m/s in a magnetic field given by (20)

$$\bar{\mathbf{B}}(y) = \hat{\mathbf{z}}0.2e^{-0.1y} \quad \text{T.}$$

If $R = 5\ \Omega$, find the current I at the instant that the loop sides are at $y_1 = 2$ m and $y_2 = 2.5$ m. The loop resistance may be ignored.

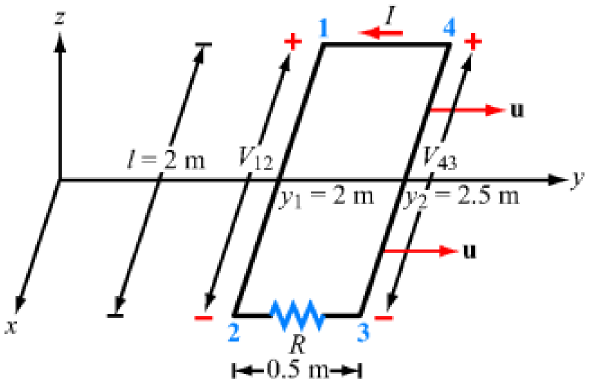


Fig. 5(b).

6. (a) A coaxial capacitor of length $l = 6$ cm uses an insulating dielectric material with $\varepsilon_r = 9$. The radii of the cylindrical conductors are 0.5 cm and 1.0 cm. If the voltage applied across the capacitor is (10)

$$V(t) = 50\sin(120\pi t) \quad \text{Volt,}$$

What is the displacement current?

(20)

(b) The magnetic field in a given dielectric medium is given by

$$\bar{\mathbf{H}} = \hat{\mathbf{y}}\,6\cos(2z)\sin(2\times 10^7 t - 0.1x) \quad \text{A/m,}$$

where x and z are in meters. Determine (i) the electric field intensity vector ($\bar{\mathbf{E}}$) and (ii) the charge density (ρ_v).

7. (a) An RHC-polarized wave with a modulus of 2 V/m is traveling in free space in the negative z-direction. Write down the expression for the wave's electric field vector, given that the wavelength is 6 cm. (10)

(b) A uniform plane wave is traveling in seawater. Assume that the xy-plane is just on the sea surface and the wave travels in the +z-direction into the water. For seawater $\epsilon_r = 80$, $\mu_r = 1$, and $\sigma = 4$ S/m. If the magnetic field at $z = 0$ is (20)

$$\bar{\mathbf{H}}(0,t) = \hat{\mathbf{y}}\ 100 \cos(2\pi \times 10^3 t + 15°) \quad \text{mA/m},$$

(i) obtain the expressions for $\bar{\mathbf{E}}(z, t)$ and $\bar{\mathbf{H}}(z, t)$,

(ii) determine the depth at which the magnitude of electric field is 1% of its value at $z = 0$,

(iii) if a submarine at a depth of 200 m below the sea surface uses a wire antenna to receive signal transmissions at 1 kHz, determine the power density incident upon the submarine antenna due to this electromagnetic wave.

8. (a) A wave traveling in a lossless, nonmagnetic medium has an electric field amplitude of 24.56 V/m and an average power density of 2.4 W/m^2. Determine the phase velocity of the wave. (10)

(b) A 200 MHz left handed circularly polarized plane wave with an electric field modulus of 5 V/m is normally incident in air upon a dielectric medium with $\varepsilon_r = 4$ and propagating along +z-direction. (20)

(i) write an expression for the electric field phasor of the incident wave, given that the field is a positive maximum at $z = 0$ and $t = 0$,

(ii) calculate the reflection and transmission coefficients, and

(iii) determine the percentages of the incident average power reflected by the boundary and transmitted into the second medium.

L-2/T-2/EEE **Date: 23/01/2021**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, BUET

L-2/T-2 B.Sc. Engineering Examinations **2019-2020**

Sub: **ME 267** (Mechanical Engineering Fundamentals)

Full Marks: 180 Time: 2 Hours

The figures in the margin indicate full marks.

Symbols used have their usual meaning and interpretation.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION-A

There are **FOUR** questions in this section. Answer any **THREE**

1. (a) Depict the actual valve-timing diagram of a four-stroke petrol engine. What is the purpose of the changes done from the ideal valve-timing diagram? **(10)**

(b) An ideal Otto cycle has a compression ratio of 8. At the beginning of the compression process, air is at 95 kPa and 27°C, and 750 kJ/kg of heat is transferred to air during the constant-volume heat-addition process. Using specific heat values at room temperature, determine (a) the pressure and temperature at the end of the heat addition process, (b) the net work output, (c) the thermal efficiency, and (d) the mean effective pressure for the cycle. **(20)**

[The properties of air at room temperature are c_p = 1.005 kJ/kg·K, c_v = 0.718 kJ/kg·K, R = 0.287 kJ/kg·K, and k = 1.4]

2. (a) What are the functions of an air handling unit in central air conditioning system. Illustrate with necessary schematic diagram. **(15)**

(b) Describe the working principle of a magnetic refrigeration system with schematic diagram. **(15)**

3. (a) Why gas turbines are used in aircraft instead of other internal combustion engines in spite of their lower thermal efficiency? Differentiate among Turbojet, Turboprop and Turbofan Gas Turbines. **(15)**

(b) Draw the block diagram and *T-s* diagram of a gas turbine with two-stage compression with intercooling, three-stage expansion with reheating, and regeneration. **(15)**

4. (a) Define critical radius of insulation. **(5)**

(b) Consider the base plate of a 800-W household iron as shown in Figure for Q. No. 4(b) with a thickness of L = 0.6 cm, base area of A = 160 cm^2, and thermal conductivity of k = 20 W/m·°C. The inner surface of the base plate is subjected to uniform heat flux generated by the resistance heaters inside. When steady operating conditions are reached, the outer surface temperature of the plate is measured to be 85°C. Disregarding any heat loss through the upper part of the iron, (*a*) express the differential equation and the boundary conditions for steady one-dimensional heat conduction through the plate, (*b*) obtain a relation for the variation of temperature in the base plate by solving the differential equation, and (*c*) evaluate the inner surface temperature. **(25)**

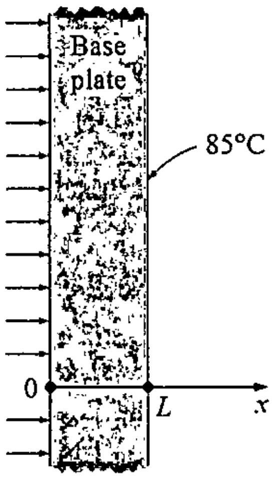


Figure for Q. No. 4(b)

SECTION-B

There are **FOUR** questions in this section. Answer any **THREE**

5. (a) "A heat-engine cycle cannot be completed without rejecting some heat to a low-temperature sink", explain the term. **(20)**

   (b) Write a short note on de-aeration of condenser. **(10)**

6. A steam power plant operates on an ideal reheat Rankine cycle between the pressure limits of 15 MPa and 10 KPa. The mass flow rate of steam through the cycle is 12 kg/s. Steam enters both stages of the turbine at 500°C. If the moisture content of the steam at the exit of the low-pressure turbine is not to exceed 10 percent, determine **(30)**
   (i) the pressure at which reheating takes place
   (ii) the total rate of heat input in the boiler
   (iii) the thermal efficiency of the cycle.

   Also, show the cycle on a T-s diagram with respect to saturation lines.

7. (a) Draw the schematic diagram of Babcock and Wilcox boiler and explain why the water tubes are kept inclined in this boiler. **(20)**

(b) Briefly explain the working principle of steam turbine. **(10)**

8. (a) What is cavitation? Explain why net positive suction head available (NPSHA) must have to be greater than net positive suction head required (NPSHR) for a pump to operate without cavitation. **(20)**

(b) Suppose that a fluid is flowing through a 2000m long pipe and the flow is developed. If the Reynolds number is 1700 at the inlet of the pipe then find the Reynolds number at the middle of the pipe. **(10)**

L-2/T-2/EEE **Date: 12/01/2021**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2018-2019

Sub: **MATH 357** (Probability and Statistics)

Full Marks: 180 Time: 2 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

Symbols used have their usual meaning.

SECTION -A

There are **FOUR** questions in this section. Answer any **THREE**.

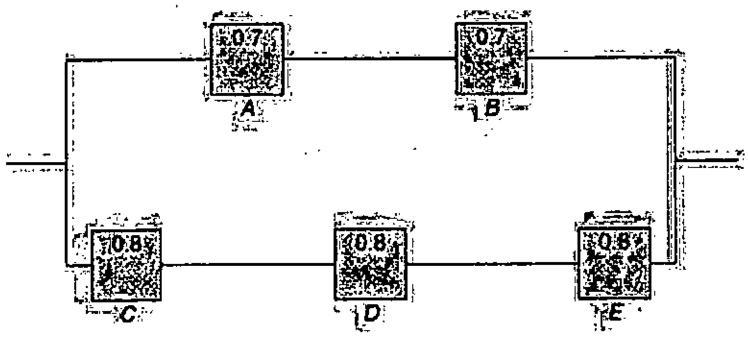
1. (a) The hospitalization period, in days, for patients following treatment for a certain type of kidney disorder is a random variable Y = X + 4, where X has the density function $f(x) = \begin{cases} \frac{32}{(x+4)^3}, & x > 0 \\ 0, & \text{elsewhere.} \end{cases}$ (15)

Find the average number of days that a person is hospitalized following treatment for this disorder.

(b) An electrical circuit system consisting of five components is illustrated in the following figure. The reliability (probability of working) of each component is also given in the figure. Assume that the components fail independently. (15)

i. Determine the probability that the entire system works?

ii. If you are given the condition that the system works, then find the probability that the component **A** is not working?



2. (a) The time to recharge the flash is tested in three cell-phone cameras. The probability that a camera meets the recharge specification is 0.8, and the cameras perform independently. (12)

i. Find the probability that the first and second cameras pass the test and the third one fails?

ii. What is the probability that the 3^{rd} failure is obtained in five or fewer tests?

(b) Changes in airport procedures require considerable planning. Arrival rates of aircraft are important factors that must be taken into account. Suppose small aircrafts arrive at a certain airport, according to a Poisson process, at the rate of 6 per hour. (18)

i. What is the probability that exactly 4 small aircraft arrive during a 1-hour period?

ii. If a working day as 12 hours has been defined, what is the probability that at least 75 small aircrafts arrive during a working day?

3. (a) A soft-drink machine is regulated so that it discharges an average of 200 milliliters per cup. If the amount of drink is normally distributed with a standard deviation equal to 15 milliliters, (10)

i. What is the probability that a cup contains between 191 and 209 milliliters?

ii. How many cups will probably overflow if 230 milliliter cups are used for the next 1000 drinks?

iii. What value do we get for the smallest 25% of the drinks? (Necessary Table 1 and Table 2 have been attached).

(b) Weibull distribution is often used to model the time until failure of many different physical systems. The random variable X with probability density function: $f(x) = \frac{\beta}{\delta}\left(\frac{x}{\delta}\right)^{\beta-1} exp\left[-\left(\frac{x}{\delta}\right)^{\beta}\right]$, $for\, x > 0$ is a Weibull random variable with scale parameter $\delta > 0$ and shape parameter $\beta > 0$. The time to failure (in hours) of a bearing in a mechanical shaft is satisfactorily modeled as a Weibull random variable with shape parameter of 1/2 and scale parameter of 5000 hours. (20)

i. Determine mean and variance of Weibull distribution by using the above definition. Hence, determine the mean time until failure of a bearing in a mechanical shaft.

ii. Determine the probability that a bearing lasts at least 6000 hours.

4. (a) A fast-food restaurant operates both a drive through facility and a walk-in facility. On a randomly selected day, let X and Y, respectively, be the proportions of the time that the drive-through and walk-in facilities are in use, and suppose that the joint density function of these random variables is (16)

$$f(x,y) = \begin{cases} \frac{2}{3}(x+2y), & 0 \le x \le 1,\ 0 \le y \le 1, \\ 0, & elsewhere. \end{cases}$$

i. Find the marginal densities of X and Y.

ii. Find the probability that the drive-through facility is busy less than one-half of the time.

(b) What do you mean by large-sample confidence interval? Scholastic Aptitude Test (SAT) mathematics scores of a random sample of 500 high school seniors in the state of Texas are collected, and the sample mean and standard deviation are found to be 501 and 112, respectively. Find a 99% confidence interval on the mean SAT mathematics score for seniors in the state of Texas. (7)

(Necessary Table 1 and 2 have been attached)

7

(c) Machine lifetime problems can be solved using different statistical distributions. If the failure of the component is a result of gradual or slow wear (as in mechanical wear), then which statistical distribution can provide more insightful results in determining lifetime. You have to explain your answer in detail providing relevant comparisons with other statistical distributions. (7)

SECTION -B

There are **FOUR** questions in this section. Answer any **THREE**.

5. **(a)** From the following distribution of travel time to work of a firm's employees, find the modal travel time **(15)**

Travel time	Less than 80	Less than 70	Less than 60	Less than 50	Less than 40	Less than 30	Less than 20	Less than 10
Frequency	218	215	195	156	85	50	18	02

(b) In two factories A and B engaged in the same industry, the average monthly wages and standard deviations are given below. Find (i) Which factory A or B pays larger amount as monthly wages? and (ii) Which factory shows greater variability in the distribution of wages? **(15)**

Factory	Average monthly wages	Standard deviation of wages	No. of wage earners
A	4600	500	100
B	4900	400	80

6. **(a)** Answer the following questions:

(i) What is a raw and central moment of a frequency distribution? Express the second, third and fourth central moments in terms of raw moments. **(15)**

(ii) What are the different measure of Skewness and Kurtosis?

(b) Following marks are obtained by 11 students in statistics in two tests, one before and the other after special tutorial class. Do the marks indicate that the special tutorial class has benefited the students? **(15)**

First test (before tutorial class)	23	20	19	21	18	20	18	17	23	16	19
Second test (after tutorial class)	24	19	22	18	20	22	20	20	23	20	17

7. **(a)** The amount of time that a drive-through bank teller spends on a customer is a random variable with a mean of 3.2 minutes and a standard deviation of 1.6 minutes. If a random sample of 64 customers is observed, find the probability that their mean time at the teller's window is **(15)**

(i) more than 3.5 minutes;
(ii) at least 3.2 minutes but less than 3.4 minutes.

(b) Air crew escape systems are powered by a solid propellant. The burning rate of this propellant is an important product characteristic. Specifications require that the mean burning rate must be 50 centimeters per second. It is known from the research that the standard deviation of burning rate is 2 centimeters per second. The experimenter decides to specify a type I error probability or significance level of 0.05 and selects a random sample of 25 and obtains a sample average burning rate of 51.3 centimeters per second. What conclusions should be drawn? **(15)**

8. **(a)** What is ANOVA? Tabulate the ANOVA table in one-way classification. **(06)**

(b) Following table gives the number of refrigerators sold by 4 salesmen in three months. **(24)**

Months	Salesmen			
	A	B	C	D
May	50	40	48	39
June	46	48	50	45
July	39	44	40	39

At 5% level of significance,
(i) Determine whether there is any significant difference in the average sales made by 4 salesmen?
(ii) Determine whether the sales differ with respect to different months?
(Necessary Tables are attached)

Necessary Tables for Question No. 3(a), 4(b) and 7(a)

Table Areas under the Normal Curve

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
−3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
−3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
−3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
−3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
−3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
−2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
−2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
−2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
−2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
−2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
−2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
−2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
−2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
−2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
−2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
−1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
−1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
−1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
−1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
−1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
−1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
−1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
−1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
−1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
−1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
−0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
−0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
−0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
−0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
−0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
−0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
−0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
−0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
−0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
−0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641

Table (continued) Areas under the Normal Curve

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

Necessary Tables for question 8(b))

F-distribution (Upper tail probability = 0.05) Numerator df = 1 to 10

df2\df 1	1	2	3	4	5	6	7	8	10
1	161.448	199.500	215.707	224.583	230.162	233.986	236.768	238.883	241.882
2	18.513	19.000	19.164	19.247	19.296	19.330	19.353	19.371	19.396
3	10.128	9.552	9.277	9.117	9.013	8.941	8.887	8.845	8.786
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.964
5	6.608	5.786	5.409	5.192	5.050	4.950	4.876	4.818	4.735
6	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.060
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726	3.637
8	5.318	4.459	4.066	3.838	3.687	3.581	3.500	3.438	3.347
9	5.117	4.256	3.863	3.633	3.482	3.374	3.293	3.230	3.137
10	4.965	4.103	3.708	3.478	3.326	3.217	3.135	3.072	2.978
11	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.854
12	4.747	3.885	3.490	3.259	3.106	2.996	2.913	2.849	2.753
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.671
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.602
15	4.543	3.682	3.287	3.056	2.901	2.790	2.707	2.641	2.544
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.494
17	4.451	3.592	3.197	2.965	2.810	2.699	2.614	2.548	2.450
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510	2.412
19	4.381	3.522	3.127	2.895	2.740	2.628	2.544	2.477	2.378
20	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.348
21	4.325	3.467	3.072	2.840	2.685	2.573	2.488	2.420	2.321
22	4.301	3.443	3.049	2.817	2.661	2.549	2.464	2.397	2.297
23	4.279	3.422	3.028	2.796	2.640	2.528	2.442	2.375	2.275
24	4.260	3.403	3.009	2.776	2.621	2.508	2.423	2.355	2.255
25	4.242	3.385	2.991	2.759	2.603	2.490	2.405	2.337	2.236
26	4.225	3.369	2.975	2.743	2.587	2.474	2.388	2.321	2.220
27	4.210	3.354	2.960	2.728	2.572	2.459	2.373	2.305	2.204
28	4.196	3.340	2.947	2.714	2.558	2.445	2.359	2.291	2.190
29	4.183	3.328	2.934	2.701	2.545	2.432	2.346	2.278	2.177
30	4.171	3.316	2.922	2.690	2.534	2.421	2.334	2.266	2.165
35	4.121	3.267	2.874	2.641	2.485	2.372	2.285	2.217	2.114
40	4.085	3.232	2.839	2.606	2.449	2.336	2.249	2.180	2.077
45	4.057	3.204	2.812	2.579	2.422	2.308	2.221	2.152	2.049
50	4.034	3.183	2.790	2.557	2.400	2.286	2.199	2.130	2.026
55	4.016	3.165	2.773	2.540	2.383	2.269	2.181	2.112	2.008
60	4.001	3.150	2.758	2.525	2.368	2.254	2.167	2.097	1.993
70	3.978	3.128	2.736	2.503	2.346	2.231	2.143	2.074	1.969
80	3.960	3.111	2.719	2.486	2.329	2.214	2.126	2.056	1.951
90	3.947	3.098	2.706	2.473	2.316	2.201	2.113	2.043	1.938

100	3.936	3.087	2.696	2.463	2.305	2.191	2.103	2.032	1.927
110	3.927	3.079	2.687	2.454	2.297	2.182	2.094	2.024	1.918
120	3.920	3.072	2.680	2.447	2.290	2.175	2.087	2.016	1.910
130	3.914	3.066	2.674	2.441	2.284	2.169	2.081	2.010	1.904
140	3.909	3.061	2.669	2.436	2.279	2.164	2.076	2.005	1.899
150	3.904	3.056	2.665	2.432	2.274	2.160	2.071	2.001	1.894
160	3.900	3.053	2.661	2.428	2.271	2.156	2.067	1.997	1.890
180	3.894	3.046	2.655	2.422	2.264	2.149	2.061	1.990	1.884
200	3.888	3.041	2.650	2.417	2.259	2.144	2.056	1.985	1.878
220	3.884	3.037	2.646	2.413	2.255	2.140	2.051	1.981	1.874
240	3.880	3.033	2.642	2.409	2.252	2.136	2.048	1.977	1.870
260	3.877	3.031	2.639	2.406	2.249	2.134	2.045	1.974	1.867
280	3.875	3.028	2.637	2.404	2.246	2.131	2.042	1.972	1.865
300	3.873	3.026	2.635	2.402	2.244	2.129	2.040	1.969	1.862
400	3.865	3.018	2.627	2.394	2.237	2.121	2.032	1.962	1.854
500	3.860	3.014	2.623	2.390	2.232	2.117	2.028	1.957	1.850
600	3.857	3.011	2.620	2.387	2.229	2.114	2.025	1.954	1.846
700	3.855	3.009	2.618	2.385	2.227	2.112	2.023	1.952	1.844
800	3.853	3.007	2.616	2.383	2.225	2.110	2.021	1.950	1.843
900	3.852	3.006	2.615	2.382	2.224	2.109	2.020	1.949	1.841
1000	3.851	3.005	2.614	2.381	2.223	2.108	2.019	1.948	1.840
∞	3.841	2.996	2.605	2.372	2.214	2.099	2.010	1.938	1.831

F-distribution (Upper tail probability = 0.05) Numerator df = 12 to 40

df2\df1	12	14	16	18	20	24	28	32	36	40
1	243.906	245.364	246.464	247.323	248.013	249.052	249.797	250.357	250.793	251.143
2	19.413	19.424	19.433	19.440	19.446	19.454	19.460	19.464	19.468	19.471
3	8.745	8.715	8.692	8.675	8.660	8.639	8.623	8.611	8.602	8.594
4	5.912	5.873	5.844	5.821	5.803	5.774	5.754	5.739	5.727	5.717
5	4.678	4.636	4.604	4.579	4.558	4.527	4.505	4.488	4.474	4.464
6	4.000	3.956	3.922	3.896	3.874	3.841	3.818	3.800	3.786	3.774
7	3.575	3.529	3.494	3.467	3.445	3.410	3.386	3.367	3.352	3.340
8	3.284	3.237	3.202	3.173	3.150	3.115	3.090	3.070	3.055	3.043
9	3.073	3.025	2.989	2.960	2.936	2.900	2.874	2.854	2.839	2.826
10	2.913	2.865	2.828	2.798	2.774	2.737	2.710	2.690	2.674	2.661
11	2.788	2.739	2.701	2.671	2.646	2.609	2.582	2.561	2.544	2.531
12	2.687	2.637	2.599	2.568	2.544	2.505	2.478	2.456	2.439	2.426
13	2.604	2.554	2.515	2.484	2.459	2.420	2.392	2.370	2.353	2.339
14	2.534	2.484	2.445	2.413	2.388	2.349	2.320	2.298	2.280	2.266
15	2.475	2.424	2.385	2.353	2.328	2.288	2.259	2.236	2.219	2.204
16	2.425	2.373	2.333	2.302	2.276	2.235	2.206	2.183	2.165	2.151
17	2.381	2.329	2.289	2.257	2.230	2.190	2.160	2.137	2.119	2.104
18	2.342	2.290	2.250	2.217	2.191	2.150	2.119	2.096	2.078	2.063

19	2.308	2.256	2.215	2.182	2.155	2.114	2.084	2.060	2.042	2.026
20	2.278	2.225	2.184	2.151	2.124	2.082	2.052	2.028	2.009	1.994
21	2.250	2.197	2.156	2.123	2.096	2.054	2.023	1.999	1.980	1.965
22	2.226	2.173	2.131	2.098	2.071	2.028	1.997	1.973	1.954	1.938
23	2.204	2.150	2.109	2.075	2.048	2.005	1.973	1.949	1.930	1.914
24	2.183	2.130	2.088	2.054	2.027	1.984	1.952	1.927	1.908	1.892
25	2.165	2.111	2.069	2.035	2.007	1.964	1.932	1.908	1.888	1.872
26	2.148	2.094	2.052	2.018	1.990	1.946	1.914	1.889	1.869	1.853
27	2.132	2.078	2.036	2.002	1.974	1.930	1.898	1.872	1.852	1.836
28	2.118	2.064	2.021	1.987	1.959	1.915	1.882	1.857	1.837	1.820
29	2.104	2.050	2.007	1.973	1.945	1.901	1.868	1.842	1.822	1.806
30	2.092	2.037	1.995	1.960	1.932	1.887	1.854	1.829	1.808	1.792
35	2.041	1.986	1.942	1.907	1.878	1.833	1.799	1.773	1.752	1.735
40	2.003	1.948	1.904	1.868	1.839	1.793	1.759	1.732	1.710	1.693
45	1.974	1.918	1.874	1.838	1.808	1.762	1.727	1.700	1.678	1.660
50	1.952	1.895	1.850	1.814	1.784	1.737	1.702	1.674	1.652	1.634
55	1.933	1.876	1.831	1.795	1.764	1.717	1.681	1.653	1.631	1.612
60	1.917	1.860	1.815	1.778	1.748	1.700	1.664	1.636	1.613	1.594
70	1.893	1.836	1.790	1.753	1.722	1.674	1.637	1.608	1.585	1.566
80	1.875	1.817	1.772	1.734	1.703	1.654	1.617	1.588	1.564	1.545
90	1.861	1.803	1.757	1.720	1.688	1.639	1.601	1.572	1.548	1.528
100	1.850	1.792	1.746	1.708	1.676	1.627	1.589	1.559	1.535	1.515
110	1.841	1.783	1.736	1.698	1.667	1.617	1.579	1.549	1.524	1.504
120	1.834	1.775	1.728	1.690	1.659	1.608	1.570	1.540	1.516	1.495
130	1.827	1.769	1.722	1.684	1.652	1.601	1.563	1.533	1.508	1.488
140	1.822	1.763	1.716	1.678	1.646	1.595	1.557	1.526	1.502	1.481
150	1.817	1.758	1.711	1.673	1.641	1.590	1.552	1.521	1.496	1.475
160	1.813	1.754	1.707	1.669	1.637	1.586	1.547	1.516	1.491	1.470
180	1.806	1.747	1.700	1.661	1.629	1.578	1.539	1.508	1.483	1.462
200	1.801	1.742	1.694	1.656	1.623	1.572	1.533	1.502	1.476	1.455
220	1.796	1.737	1.690	1.651	1.618	1.567	1.528	1.496	1.471	1.450
240	1.793	1.733	1.686	1.647	1.614	1.563	1.523	1.492	1.466	1.445
260	1.790	1.730	1.683	1.644	1.611	1.559	1.520	1.488	1.463	1.441
280	1.787	1.727	1.680	1.641	1.608	1.556	1.517	1.485	1.459	1.438
300	1.785	1.725	1.677	1.638	1.606	1.554	1.514	1.482	1.456	1.435
400	1.776	1.717	1.669	1.630	1.597	1.545	1.505	1.473	1.447	1.425
500	1.772	1.712	1.664	1.625	1.592	1.539	1.499	1.467	1.441	1.419
600	1.768	1.708	1.660	1.621	1.588	1.536	1.495	1.463	1.437	1.414
700	1.766	1.706	1.658	1.619	1.586	1.533	1.492	1.460	1.434	1.412
800	1.764	1.704	1.656	1.617	1.584	1.531	1.490	1.458	1.432	1.409
900	1.763	1.703	1.655	1.615	1.582	1.529	1.489	1.457	1.430	1.408
1000	1.762	1.702	1.654	1.614	1.581	1.528	1.488	1.455	1.429	1.406
∞	1.752	1.692	1.644	1.604	1.571	1.517	1.476	1.444	1.417	1.394