

GATE 2023 Agricultural Engineering Question Paper

Total Time Allowed : 3 hours	Maximum Marks : 100	Total Questions : 65
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General Instructions

Read the following instructions very carefully and strictly follow them:

This question paper is divided into three sections:

1. The total duration of the examination is 3 hours.
2. The total number of questions is **65**, carrying a maximum of **100 marks**.
3. The marking scheme is as follows:
 - (i) For 1-mark MCQs, $\frac{1}{3}$ mark will be deducted for every incorrect response.
 - (ii) For 2-mark MCQs, $\frac{2}{3}$ mark will be deducted for every incorrect response.
 - (iii) No negative marking for numerical answer type (NAT) questions.
4. No marks will be awarded for unanswered questions.
5. Follow the instructions provided during the exam for submitting your answers.

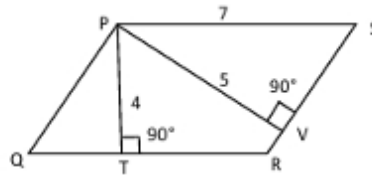
1. "You are delaying the completion of the task. Send _____ contributions at the earliest."

- (A) you are
- (B) your
- (C) you're
- (D) yore

2. References : _____ :: Guidelines : Implement (By word meaning)

- (A) Sight
- (B) Site
- (C) Cite
- (D) Plagiarise

3. In the given figure, PQRS is a parallelogram with PS = 7 cm, PT = 4 cm and PV = 5 cm. What is the length of RS in cm? (The diagram is representative.)

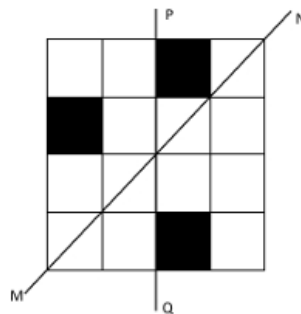


- (A) $\frac{20}{7}$
 (B) $\frac{28}{5}$
 (C) $\frac{9}{2}$
 (D) $\frac{35}{4}$

4. In 2022, June Huh was awarded the Fields medal. He was also a poet, did not win any medals in the International Mathematics Olympiads, and dropped out of college. Based only on this information, which statement can be inferred with certainty?

- (A) Every Fields medalist has won a medal in an International Mathematics Olympiad.
 (B) Everyone who has dropped out of college has won the Fields medal.
 (C) All Fields medalists are part-time poets.
 (D) Some Fields medalists have dropped out of college.

5. A line of symmetry is a line that divides a figure into two parts in a way such that each part is a mirror image of the other part about that line. The given figure consists of 16 unit squares arranged as shown. In addition to the three black squares, what is the minimum number of squares that must be coloured black, such that both PQ and MN form lines of symmetry? (The figure is representative.)



- (A) 3
 (B) 4
 (C) 5

(D) 6

6. Human beings are one among many creatures that inhabit an imagined world. In this world, some creatures are cruel. If it is given that the statement "Some human beings are not cruel creatures" is FALSE, then which of the following statements can be logically inferred with certainty?

- (i) All human beings are cruel creatures.
- (ii) Some human beings are cruel creatures.
- (iii) Some creatures that are cruel are human beings.
- (iv) No human beings are cruel creatures.

- (A) only (i)
- (B) only (iii) and (iv)
- (C) only (i) and (ii)
- (D) (i), (ii) and (iii)

7. To construct a wall, sand and cement are mixed in the ratio 3 : 1. The costs per unit of sand and cement are in the ratio 1 : 2. If the total cost of sand and cement is 1000, what is the cost (in rupees) of cement used?

- (A) 400
- (B) 600
- (C) 800
- (D) 200

8. The World Bank has declared that it will not offer new financing to Sri Lanka until the country has an adequate macroeconomic policy framework. It adds that Sri Lanka needs structural reforms for stabilisation and to tackle root causes of the crisis. The crisis has starved the country of foreign exchange and led to shortages of essentials. The Bank is repurposing existing loans to ease shortages. Based only on this passage, which statement can be inferred with certainty?

- (A) According to the World Bank, the root cause of Sri Lanka's crisis is a lack of foreign exchange.
- (B) The World Bank has stated that it will advise Sri Lanka about how to tackle the root causes.

- (C) According to the World Bank, Sri Lanka does not yet have an adequate macroeconomic policy framework.
- (D) The World Bank has stated that it will provide additional funds for essentials.
-

9. The coefficient of x^4 in $(x - 1)^3(x - 2)^3$ is equal to -----

- (A) 33
(B) -3
(C) 30
(D) 21
-

10. Which one of the following shapes can be used to tile (completely cover by repeating) a flat plane, extending to infinity in all directions, without leaving any empty spaces in between them? The copies of the shape used to tile are identical and not allowed to overlap.

- (A) circle
(B) regular octagon
(C) regular pentagon
(D) rhombus
-

11. If A and B are square matrices of order 3 such that $|A| = -1$ and $|B| = 3$, then $|3AB|$ equals:

- (A) -81
(B) -27
(C) -9
(D) 81
-

12. Evaluate the limit $\lim_{x \rightarrow 0} \frac{\sqrt{1+x}-1}{x}$

- (A) 0
(B) $\frac{1}{2}$
(C) 1

(D) 2

13. The value of $I = \int_0^{\pi/2} \frac{(\sin x + \cos x)^2}{\sqrt{1 + \sin 2x}} dx$ is:

- (A) 0
 - (B) 1
 - (C) 2
 - (D) 3
-

14. $y = ae^{mx} + be^{-mx}$ is the solution of the differential equation:

- (A) $\frac{dy}{dx} - my = 0$
 - (B) $\frac{dy}{dx} + my = 0$
 - (C) $\frac{d^2y}{dx^2} + m^2y = 0$
 - (D) $\frac{d^2y}{dx^2} - m^2y = 0$
-

15. In rotary tiller, the total energy requirement for carrying out tillage will decrease if

- (A) the bite length is increased
 - (B) the bite length is decreased
 - (C) the cone index of soil is higher
 - (D) forward speed of the machine is reduced
-

16. The effectiveness of the turbocharger of a diesel engine increases when

- (A) the ambient temperature increases
 - (B) the pressure ratio across the compressor decreases
 - (C) the load on the engine increases
 - (D) the displacement volume of the engine decreases
-

17. In a thresher, the cylinder separation efficiency can be improved by increasing

- (A) cylinder diameter
 - (B) cylinder speed
 - (C) cylinder-concave clearance
 - (D) feed rate
-

18. In a 4-stroke single cylinder diesel engine, the inlet valve opens at 10° before TDC and closes at 40° after BDC. The exhaust valve opens at 25° before BDC and closes at 15° after TDC. The percentage of time for which both valves remain closed in one engine cycle is

- (A) 32.29
 - (B) 40.97
 - (C) 46.53
 - (D) 75.01
-

19. The torque available at maximum power developed by the tractor is 150 Nm. If the reserve torque is 20%, the peak torque that can be developed by the tractor (in Nm) is

- (A) 100
 - (B) 120
 - (C) 180
 - (D) 210
-

20. The statement which is not correct for the porous medium is

- (A) Seepage velocity is always greater than the Darcy's velocity
 - (B) Darcy's velocity is not exclusively controlled by soil porosity
 - (C) Seepage velocity increases with increasing surface ponding of water
 - (D) Darcy's velocity in unsaturated soil is always greater than that in saturated soil
-

21. A sprinkler irrigation system has been designed for a crop with the water application rate of 1.17 cm h^{-1} and sprinkler discharge of 1.3 L s^{-1} . The co-

efficient of discharge and uniformity coefficient are 0.9 and 0.8, respectively. If the sprinkler spacing along the lateral is 20 m, the lateral spacing in m is

- (A) 14.4
- (B) 16.0
- (C) 18.0
- (D) 20.0

22. The average discharge, operating pressure and emitter constant of a drip emitter are 4 L h^{-1} , 110 kPa and 0.3, respectively. The type of emitter is

- (A) orifice
- (B) long path
- (C) pressure compensating
- (D) disc

23. If the departure and latitude of a line are 70 m and -130 m, respectively, then the whole circle bearing (WCB) of the line in degrees is

- (A) 28
- (B) 62
- (C) 152
- (D) 208

24. Match the Columns:

I	II
1. Tensiometer	a. Consumptive use
2. Piezometer	b. Bernoulli's equation
3. Lysimeter	c. Soil moisture
4. Elbow meter	d. Hydrostatic pressure
5. Pitot tube	e. Volumetric flow rate

- (A) 1-c, 2-b, 3-a, 4-e, 5-d
- (B) 1-c, 2-d, 3-a, 4-e, 5-b
- (C) 1-d, 2-c, 3-e, 4-a, 5-b
- (D) 1-c, 2-d, 3-a, 4-b, 5-e

25. The information needed for estimating the design flood using Rational formula is:

- (A) cumulative infiltration
 - (B) antecedent moisture condition of soil
 - (C) shape factor of the catchment
 - (D) time of concentration of the catchment
-

26. The microbial death kinetics for a food suspension follows the equation:

$$\log \frac{N_0}{N} = 1 + \frac{t - t_L}{D}$$

where N_0 = initial microbial load, N = microbial load after time t , t_L = lag time, and D = decimal reduction time.

The correct statement for this equation is:

- (A) the time required to reduce 10% of the initial population is lag time.
 - (B) the time required to reduce the initial 90% of population is lag time.
 - (C) time required to kill the first 90% population is lower than D value at the same temperature.
 - (D) lag time approaches D value as N_0 becomes smaller and temperature decreases.
-

27. If the diameter of fat globule in a cream separator is reduced to half and the rotational speed of the centrifuge increased to three times, the terminal settling velocity of fat globule is:

- (A) decreased to 0.44 times
 - (B) increased to 0.44 times
 - (C) decreased to 2.25 times
 - (D) increased to 2.25 times
-

28. The log mean temperature difference (LMTD) correction factor is not required during heat transfer rate calculation in:

- (A) plate heat exchanger
- (B) 1 shell pass and 1 tube pass heat exchanger

- (C) 1 shell pass and 2 tube pass heat exchanger
 - (D) 2 shell pass and 4 tube pass heat exchanger
-

29. Identify the dimensionless parameter(s) from the following:

- (A) Cone index
 - (B) Puddling index
 - (C) Performance index
 - (D) Reel index
-

30. The probability that a storm event with a return period of 20 years will occur once in a 5-year period is _____ (rounded off to 2 decimal places).

31. Considering declining balance method, the constant rate of depreciation at which the value of the tractor will come down to 50% of its purchase price at the end of 4th year (in percent) is _____ (rounded off to 2 decimal places).

32. A trapezoidal grassed waterway with side slope (H:V) of 1:1 carries a design discharge of $1 \text{ m}^3/\text{s}$. The bed slope and Manning's roughness coefficient of this channel are 1% and 0.04, respectively. The design depth of the best hydraulic trapezoidal grassed waterway section in m is _____ (rounded off to 2 decimal places).

33. The minimum fluidization height of 1.20 m is maintained during fluidized bed drying of carrots. The bed diameter of the fluidized bed dryer is 0.6 m. If mass and solid density of carrots are 250 kg and 1040 kg/m^3 , respectively, then the porosity of the bed at the minimum fluidization condition is _____ (rounded off to 3 decimal places, $\pi = 3.14$).

34. The lighter liquid layer and the interphase layer in a basket centrifuge, rotating at a speed of 1000 rpm, are 0.1025 m and 0.105 m away from the

center, respectively. Considering the densities of lighter and heavier liquids as 920 kg/m^3 and 1015 kg/m^3 , the differential pressure in horizontal direction required to maintain the interphase layer in kPa is _____ (rounded off to 3 decimal places, $\pi = 3.14$).

35. The upstream and downstream pressures in a homogenizer during homogenization of milk are maintained at 250 bar and 10 bar, respectively. If density of milk is 1030 kg/m^3 , then the velocity at which milk comes out of the homogenizing valve in m/s is _____ (rounded off to 3 decimal places).

36. If $A = \begin{pmatrix} 1 & -1 \\ 2 & -1 \end{pmatrix}$, $B = \begin{pmatrix} a & 1 \\ b & -1 \end{pmatrix}$ and $(A + B)^2 = A^2 + B^2$, then the values of a and b are:

- (A) $a = 4, b = 1$
 - (B) $a = 1, b = 4$
 - (C) $a = 0, b = 4$
 - (D) $a = 2, b = 4$
-

37. A vector $\vec{F} = 5\hat{i} - 10\hat{j} + 8\hat{k}$ is passing through the origin of a 3-D frame. Considering the tendency of rotation in the counter clockwise direction as positive, the moment about a point A: (3, 4, 8) is:

- (A) $-16\hat{i} + 112\hat{j} + 50\hat{k}$
 - (B) $112\hat{i} + 16\hat{j} - 50\hat{k}$
 - (C) $50\hat{i} - 112\hat{j} + 16\hat{k}$
 - (D) $-112\hat{i} - 16\hat{j} + 50\hat{k}$
-

38. A vertical disc plough with 5 discs is operated at a depth of 0.15 m. The disc angle and disc diameter are 40° and 0.6 m, respectively. If overlap between two consecutive discs is 0.12 m at 0.15 m depth of cut, the total width of cut at the specified depth in m is:

- (A) 1.19
- (B) 1.55

39. In a 9×20 cm fluted roller type seed drill, each fluted roller is discharging 4.25 g of seed per revolution of fluted roller shaft. The fluted roller shaft rotates once for two complete rotations of the ground drive wheel of the seed drill. The rolling diameter of the ground drive wheel is 0.35 m. Considering no skid of the ground drive wheel, the seed rate in kg/ha is (take $\pi = 3.14$):

- (A) 96.62
- (B) 141.55
- (C) 187.35
- (D) 386.42

40. A field sprayer with 12 nozzles fitted to the boom at a spacing of 0.5 m is used for spraying at a height of 0.75 m from the ground. The angle of spraying is 75° . If the height of spraying is reduced to 0.6 m, the change in swath in m is:

- (A) 0.23
- (B) 0.48
- (C) 0.65
- (D) 0.91

41. The ordinates of a 6-hour S-hydrograph of a catchment are given in the table. The catchment has phi-index of 0.25 cm h^{-1} and baseflow of $10.5 \text{ m}^3/\text{s}$. The peak of the flood hydrograph generated from this catchment due to a storm of 45 mm received during the first 6 h in m^3/s is:

Time (h)	0	6	12	18	24	30	36	42	48
Ordinate (m^3/s)	0	30	90	180	252	306	342	360	360

- (A) 259.5
- (B) 270.0
- (C) 280.5
- (D) 349.5

42. It is planned to provide irrigation in a crop field having field capacity and permanent wilting point of the soil as $0.21 \text{ cm}^3/\text{cm}^3$ and $0.09 \text{ cm}^3/\text{cm}^3$, respectively. The crop root zone depth is 0.90 m. The growing period of this

crop is 1st January to 31st March, during which the observed reference evapotranspiration (ET_r), effective rainfall (P_e) and crop coefficients (K_c) are given:

Month	ET_r (mm/day)	P_e (mm/month)	K_c
January	11	8	0.80
February	12	25	1.10
March	14	27	1.15

Considering management allowable deficit (MAD) for this crop as 50%, the average irrigation interval during the growing period in days is:

- (A) 4
- (B) 6
- (C) 8
- (D) 11

43. The infiltration capacity of a basin is described by Horton's equation: $I = 2 + e^{-3t}$ where I is in cm/h and t is in hours. If the duration of the storm event is 2 hours, the depth of infiltration in the last 1 hour of the storm event in mm is:

- (A) 5
- (B) 10
- (C) 20
- (D) 25

44. In a juice filtration process, solid concentration per m^3 of filtrate is 0.2 kg. During filtration of $12.49 m^3$ of juice, 0.02 m thick cake (porosity of 0.32) is deposited. If 2.5 kg of solid is collected in 180 s, the pressure drop across the cake in kPa is:

Absolute viscosity of juice = $2.12 \times 10^{-3} \text{ kg m}^{-1}\text{s}^{-1}$, Specific cake resistance = $1.2 \times 10^8 \text{ m kg}^{-1}$

- (A) 0.18
- (B) 1.81
- (C) 18.06
- (D) 180.60

45. Cheese is packed in a bilayer plastic package made of low density polyethylene (LDPE) and polyethylene terephthalate (PET). Thickness of LDPE and PET in the package are 1.5 mm and 1.3 mm, respectively. The surface area of the plastic package is 6.25 cm^2 . The partial pressure difference of oxygen across the package wall is 0.30 atm. The permeability coefficient of oxygen in LDPE and PET are $4.18 \times 10^{-8} \text{ cm cm}^2 \text{ s}^{-1} \text{ atm}^{-1}$ and $1.67 \times 10^{-10} \text{ cm cm}^2 \text{ s}^{-1} \text{ atm}^{-1}$, respectively. If the food gets spoiled when it absorbs 0.025 ml oxygen, then the shelf life of food in days is:

- (A) 121
- (B) 103
- (C) 73
- (D) 61

46. The rotor shaft of an ice cream freezer consists of 3 scraper blades. The temperature difference between the ice cream mix and the refrigerant during freezing of ice cream is 30°C . Density and latent heat of fusion of ice are 917 kg m^{-3} and 335 kJ kg^{-1} , respectively. The overall heat transfer coefficient is $2000 \text{ kJ m}^{-2} \text{ h}^{-1} \text{ }^\circ\text{C}^{-1}$. If the maximum thickness of ice formed before being scraped off is 10 m, the minimum speed of the scraper shaft in rpm is:

- (A) 88
- (B) 109
- (C) 121
- (D) 149

47. The percentage absolute humidity of air becomes equal to the percentage relative humidity, when:

- (A) absolute humidity of air is equal to relative humidity
- (B) saturated humidity of air is equal to relative humidity
- (C) air is almost or completely dry
- (D) air is almost or completely saturated

48. Dimensionless numbers play an important role in correlating transfer coefficients during forced convection. In relation to the dimensionless numbers, the correct statement(s) is/are:

- (A) Prandtl number in heat transfer is analogous to Schmidt number in mass transfer
 - (B) Small value of Prandtl number signifies lower thermal diffusion as compared to momentum diffusion
 - (C) Prandtl number is the ratio of momentum diffusivity to the thermal diffusivity of the fluid
 - (D) Lewis number is the product of Schmidt number and Prandtl number
-

49. In a locality 'A', the probability of a convective storm event is 0.7 with a density function

$$f_{X_1}(x_1) = e^{-x_1}, \quad x_1 > 0$$

The probability of a tropical cyclone-induced storm in the same location is given by the density function

$$f_{X_2}(x_2) = 2e^{-2x_2}, \quad x_2 > 0$$

The probability of occurring more than 1 unit of storm event is _____ (rounded off to 2 decimal places).

50. Given that $\frac{dy}{dx} = 2x + y$, $y(0) = 1$. Using Runge-Kutta fourth order method, the value of y at $x = 0.2$ is _____ (rounded off to 3 decimal places).

51. A power operated chaff cutter with a mean cutting radius of 0.25 m is fitted with two cutting knives and is rotating at 300 rpm. Thirty maize stalks with a mean diameter of 12 mm are fed through the throat at a time. The dynamic shear strength of the stalk is 0.05 N mm^{-2} . The mass and radius of gyration of the flywheel (including knives) are 40 kg and 0.27 m, respectively. The total shaft power requirement in kW is _____ (rounded off to 2 decimal places).

52. A two-wheel drive tractor with a total weight of 24 kN has a static weight distribution of 30% and 70% at the front and rear axles, respectively. When the tractor is operated on a level ground of pure sand, the maximum tractive force developed is 13 kN. If external weight of 1.5 kN is added to the rear axle, neglecting weight transfer, the change in maximum tractive force in kN

is -----.

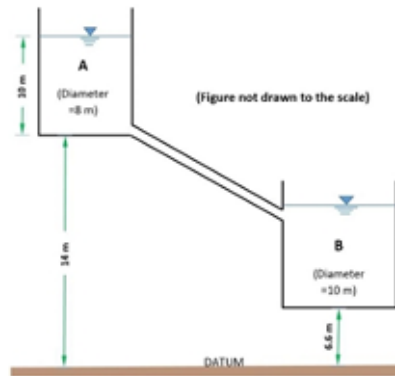
53. A 4-stroke diesel engine can be operated with either diesel ($HV = 45$ MJ/kg) or biodiesel B20 ($HV = 42.1$ MJ/kg). Brake specific fuel consumption: diesel = 260 g/kWh, B20 = 310 g/kWh. For brake power = 20 kW, the change in brake thermal efficiency of the engine when B20 is used is ----- %.

54. A solar photovoltaic system receives radiations between 400-750 W/m². Efficiency = 14%. Cell parameters: $V_{oc} = 21.6$ V, $I_{sc} = 3.22$ A, fill factor = 0.72. Find minimum cell area required to generate 10 kW power.

55. A single disc clutch is used to transmit 10 kW power at 1400 rpm. The axial pressure = 0.07 N/mm², coefficient of friction = 0.25, ratio of inner to outer radius = 0.8. If the uniform wear theory applies, the required face width of clutch lining is ----- mm.

56. In a tractor seat system, the chassis frequency and seat suspension damping rate are 20 rad s⁻¹ and 400 N m⁻¹ s, respectively. The critical damping rate of the tractor seat system is 1600 N m⁻¹ s. If the combined mass of the seat and operator is 80 kg, the transmissibility of vibration is ----- (rounded off to 2 decimal places).

57. Two cylindrical reservoirs 'A' and 'B' are connected by a 30 m long pipe of 250 mm internal diameter as shown. Darcy friction factor for the pipe is 0.025. Initially reservoir 'A' was full and reservoir 'B' was empty. Neglecting entrance and exit losses, find the time required to empty reservoir 'A' in hours (rounded off to 3 decimal places).



58. A homogenous anisotropic earthen dam of height 52 m with a free board of 2 m is constructed on an impermeable foundation. The horizontal and vertical hydraulic conductivities of soil are $K_h = 4.5 \times 10^{-8}$ m/s and $K_v = 2.0 \times 10^{-8}$ m/s. There are 6 flow channels and 25 equipotential drops in a square flownet drawn in the transformed dam section. If the downstream dam side is dry, the quantity of seepage per unit length through the dam in $\text{m}^3/\text{day}/\text{m}$ is -----.

59. A salt affected crop field is to be leached with irrigation water having salt concentration of 3.5 meq/L. Salt concentration in saturation extract of soil is 15.2 meq/L. Leaching efficiency of field = 55%. In March, $ET_o = 150$ mm, effective rainfall = 75 mm, crop coefficient = 1.05. Find leaching requirement for the month in mm.

60. A 10 m pipe carries peak discharge = $1 \text{ m}^3/\text{s}$, head = 4 m, entrance loss coefficient = 0.5, friction loss coefficient = 0.02. Find neutral slope of water level in %.

61. Discharge from centrifugal pump at 1000 rpm with head = 30 m is 300 L/min. Efficiency = 65%. If speed increases to 1200 rpm, find power required.

62. A 0.30 m well penetrates an unconfined aquifer (saturated depth = 40 m). Pumping $0.03 \text{ m}^3/\text{s}$ for 8 hours. Drawdowns in two observation wells: 3

m at 20 m, 2 m at 50 m. Find drawdown in pumping well in m.

63. The apparent wall shear stress in a 0.6 m long pipe line carrying refined oil is 12.5 Pa. If the pressure drop along the length is 300 Pa and flow rate is $0.25 \text{ m}^3/\text{s}$, the absolute viscosity of oil in $10^{-3} \text{ Pa}\cdot\text{s}$ is

64. The carrot slices (water activity = 0.89) are to be preserved using osmo-dehydration. Addition of salt (NaCl) to 20% sucrose solution (water activity = 0.987) reduces the water activity to 0.85. Find the percentage of NaCl added to the solution. (Molecular mass of sucrose = 342, molecular mass of NaCl = 58.44).

65. A copper ball and a steel ball having diameters d_1 and d_2 , respectively, are initially at 200°C . Both are cooled to ambient 30°C . If both reach 120°C in equal duration, find ratio d_1/d_2 . Assume Biot ≤ 0.1 .
