

KATHMANDU UNIVERSITY  
End Semester Examination  
June/July, 2023

Marks Scored:

Level : B.E.

Year : III

Exam Roll No. :

Time: 30 mins.

Course : CHEG 305

Semester : II

F. M. : 10

Registration No.:

Date

29 JUN 2023

SECTION "A"

[20 Q.  $\times$  0.5 = 10 marks]

Encircle the most appropriate answer.

1. In a CSTR, what type of model is generally used?  
a. lumped      b. distributed      c. stochastic      d. ANN
2. Estimation of parameters in a model is generally done during:  
a. conceptualization      b. calibration      c. validation      d. application
3. The time constants in an unsteady catalytic tubular reactor may be very different for different phenomena. What is the time scale at which this process may be properly modeled?  
a. seconds      b. days      c. weeks      d. years
4. If you want to understand the absorption process in an industry, what type of model will you use?  
a. statistical      b. mechanistic      c. linear      d. lumped
5. What type of functions of specific volume can you convert the Equations of State to?  
a. linear      b. exponential      c. quadratic      d. cubic
6. When a toxic chemical is accidentally released into the atmosphere, which model can be the best suitable to simulate its impact?  
a. dispersion      b. ANN      c. fuzzy logic      d. CSTR
7. When you want to have an equally sliced samples over an interval, which Numpy function will you generally use?  
a. curve\_fit      b. linspace      c. meshgrid      d. brentq
8. Which adsorption isotherm plots a straight line if  $1/(adsorbate/adsorbent)$  is plotted against  $1/(concentration\ of\ adsorbate)$ ?  
a. Freundlich      b. Radke      c. Exponential      d. Langmuir
9. Which one of the following models does not consist of bulk flow or convection?  
a. CFD      b. Eulerian      c. Transport      d. Lagrangian
10. Which one of the following can be applied in a fluidized bed with very fine particles?  
a. adiabatic      b. continuum      c. plug flow      d. mixed flow
11. What is generally valid while solving Navier Stokes equation for a cavity flow?  
a. velocity components are zero everywhere  
b.  $u$ -component is non-zero in lid of the cavity  
c.  $u$ -component is zero in lid of the cavity  
d. velocity components are zero in lid of the cavity

12. When solving Navier Stokes model numerically, what is used to check the stability of the numerical iterations?
- a. Reynolds number
  - b. Courant number
  - c. Prandtl number
  - d. Diffusivity
13. What happens to the number concentration of flocs in flocculation inside a stirred reactor tank after a long time?
- a. small flocs increase, larger flocs increase
  - b. small flocs increase, larger flocs decrease
  - c. small flocs decrease, larger flocs increase
  - d. small flocs decrease, larger flocs decrease
14. Population balance model can be used to simulate:
- a. detergent granulation
  - b. steam flow
  - c. toothpaste flow
  - d. alcohol distillation
15. Which function is generally used as activation function in feedforward ANN?
- a. sigmoid
  - b. cubic
  - c. logarithmic
  - d. Bessel
16. What acts as an activation threshold in a perceptron?
- a. weight matrix
  - b. bias
  - c. backpropagated error
  - d. hidden layer
17. When an ANN can well-simulate even the noise in the data, the condition is known as:
- a. unstable
  - b. optimal training
  - c. under-fitting
  - d. over-fitting
18. In the Python implementation of an ANN model, which one of the following can be used to normalize the data?
- a. StandardScaler
  - b. MLPClassifier
  - c. sklearn.metrics
  - d. scipy.optimize
19. What is used to investigate how the variation in the output of a numerical model can be attributed to the variation of the input factors?
- a. calibration
  - b. sensitivity analysis
  - c. stability analysis
  - d. parameter optimization
20. An example of the pattern search method in sensitivity analysis is:
- a. Monte Carlo
  - b. Direct Differential
  - c. FAST
  - d. SIMPLE

29 JUN 2023

Level : B.E.  
 Year : III  
 Time : 2 hrs. 30 mins.

Course : CHEG 305  
 Semester : II  
 F. M. : 40

SECTION "B"

Attempt *ALL* questions. The data or information not given in the questions should be assumed properly.

1. Briefly explain five distinct and widely-known applications of modeling and simulation in chemical engineering. [5]
2. Consider a dryer, which is a long tube. Some solid particles are conveyed by superheated steam inside the dryer.
  - a. What are the main processes that may need to be modeled? [1]
  - b. How would you classify the models to represent those processes? [2]
  - c. What kind of calibration can be used in those models? [2]
  - d. Propose a method to validate those models. [1]
3. A large, poorly controlled copper smelter has a stack 150 m high and a plume rise of 75 m. It is currently emitting 1500 g/s of SO<sub>2</sub>.
  - a. Estimate the ground-level concentration of SO<sub>2</sub> from this source at a distance 5 km directly downwind when the wind speed is 3 m/s and the stability class is C. Horizontal dispersion coefficient and vertical dispersion coefficient at this downwind distance for class C stability are 400 m and 300 m respectively. [4]
  - b. An engineer found that this concentration was twice the allowable. She proposed to remedy this situation by installing a higher stack. How high must this stack be approximately so that the estimated concentration will be exactly one-half of that in Q.3(a)? [2]
4. Show the data difference algebraic equivalent of the unsteady-state one-dimensional laminar flow equation. Then explain why implicit solution may solve stability problem along with the significance of time step and grid size. [3+3]
5. Consider a population of cells flowing through a plug flow reactor. The cells are characterized at time *t* by their position, *x*, and their mass, *m*. They are supposed to grow, to die, and to divide into two daughter cells.
  - a. Illustrate the trajectories of the cells in the physical space domain and in the mass-time domain. [2]
  - b. What will be the mass balance model for this system? [3]
6. An artificial neural network model is being used in detection and diagnosis of process faults in the absorption of CO<sub>2</sub> gas in monoethanolamine (MEA) in an absorption and stripping pilot plant.
  - a. How would you train the model? [2]
  - b. If the training of the model fails, what may be the causes and how will you solve them? [2]
  - c. Explain the use of simulated data as a source of data to train the model. [2]
7. Let  $z(x) = (0.85 - n x)(300 + m x) - 0.55 x$  with the nominal values of  $m = 9$ ;  $n = 0.02$ .
  - a. What is the absolute sensitivity of *x* to *m*? [3]
  - b. What is the relative sensitivity of *x* to *m*? [1]
  - c. What are the limitations of the local sensitivity analysis? [2]

**KATHMANDU UNIVERSITY**  
End Semester Examination [C]  
November/December, 2023

### Marks Scored:

Level : B.E.

Year : III

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Exam Roll No. : \_\_\_\_\_

Time: 30 mins.

**Course : CHEG 305**

Semester : II

E.M. : 10

**Registration No.:**

26 NOV 2023

**SECTION “A”**  
[20 Q.  $\times$  0.5 = 10 marks]

**Choose and encircle in the most appropriate option.**

- If you are asked to find the optimal input variables for obtaining a desired output, what is this problem known as?
    - design problem
    - simulation problem
    - rating problem
    - dynamic problem
  - What type of simulation is used to train plant operators to quickly respond to the changing behavior of the system and take appropriate actions?
    - stochastic
    - dynamic
    - static
    - lumped
  - What type of model would you use to solve a momentum balance equation in the case of steady state and 3D?
    - Fick's
    - CFD
    - ANN
    - dispersed-phase
  - For process modifications, you may require simulation to test and add a new equipment. What type of system is used for repeated simulation of your designs?
    - linear computing
    - static computing
    - stochastic computing
    - parallel computing
  - What model is used to immediately simulate the spread of fire in an industrial accident?
    - dispersion
    - CFD
    - ANN
    - static 3D
  - Which one of the following is a stochastic and discrete-event model?
    - diffusion
    - advection
    - population balance
    - PFR
  - In Peng-Robinson EOS, what does the largest real root correspond to?
    - gas phase
    - liquid phase
    - catalytic reaction
    - interphase transport
  - Which one of the following is applicable only in the absence of convection?
    - CFD
    - advection
    - Fick's law
    - Navier-Stokes
  - In heat transfer, what do you use to provide boundary conditions of the second kind?
    - Fick's law
    - Fourier's law
    - temperature
    - heat transfer coefficient
  - What is the most suitable model to design a stirred-tank reactor?
    - lumped
    - probabilistic
    - distributed
    - static
  - In Eulerian-Lagrangian model, dispersed units are modeled as:  
Langrangian



KATHMANDU UNIVERSITY  
End Semester Examination [C]  
November/December, 2023

Level : B.E.  
Year : III  
Time : 2 hrs. 30 mins.

26 NOV 2023

Course : CHEG 305  
Semester : II  
F.M. : 40

SECTION "B"  
[8Q × 5 = 40 marks]

Attempt *ALL* questions. The data or information not given in the questions should be assumed properly.

1. Provide three real-world examples of static models used in different industrial and chemical engineering processes. When do you need to substitute these models with dynamic models? [3+2]
2. There is a model being used in an industry for simulation of reactors in series. You are asked to evaluate the performance of the model and report any limitations of the model. What procedure would you apply for this? [5]
3. A chemical plant is emitting 0.332 kg/s of VOC from an exhaust that is 45 m above ground-level. Due to the gas velocity, the plume is rising 6 m vertically. The weather station reports that the wind is blowing at 4.4 m/s. What will be the concentration of the emitted VOC that affects people walking in the nearby road, which is downwind from the source at the centerline if the horizontal and vertical dispersion parameters are 200 m and 150 m respectively? [5]
4. Construct any CFD equation using numerical method. Then discuss the importance of stability and Courant condition in CFD simulations in Chemical Engineering. [3+2]
5. What kind of model is a CSTR? How does it differ from the model of a tubular reactor? [3+2]
6. Differentiate between dispersed-phase vector and continuous-phase vector. How can you change the number and size of dispersed phase? [2+3]
7. How can process simulators be useful for ANN model development? What is a back propagation algorithm? [2+3]
8. How do you use integral of the absolute value of the error to validate models? How do you obtain sensitivity equations? [3+2]

SECTION "B"

Answer ALL questions. The data or information not given in the questions should be assumed properly.

1. What is the importance of modeling and simulation in the following?  
a. Integrated multi-scale approach for chemical product design and manufacturing [1]  
b. Supply chain management [1]  
c. Process design problems [1]  
d. Equipment design [1]  
e. Process safety [1]
2. In modeling and simulation, explain the following:  
a. Factors affecting the selection of software [2]  
b. Application of steady-state model in chemical engineering [2]  
c. Application of dynamic models in chemical engineering [2]  
d. Use of quasi-steady state assumption [1]
3. a. At a given temperature do you think mass diffusivity of air in water vapor will be equal to mass diffusivity of water in air? [1]  
b. What is the advantage of using class compared to function in Python? Write a simple program that calculates the temperature using ideal gas law using functions. [1+2]  
c. What are the similarities and differences between Fick's law and Fourier's law of heat conduction? In which condition is the Fick's second law applicable? [2+1]
4. a. Explain in detail how the change in diameter changes the temperature, flow rate and temperature in a plug flow parallel reactor with exothermic reaction. [3]  
b. Give two examples of system or problem that can be modeled using compartmental model. [2]
5. Consider the following system:  $dA/dt = 2A - 3B$  and  $dB/dt = 5AB - 4B$ , where A and B are populations of two chemical species, and t is time. What type of model is it? What does the model tells about relationship between the two species? Explain with a graph. [1+3]
6. How does the information get processed in a single neuron of an Artificial Neural Network? Provide the application of back-propagation neural network model in monitoring the chemical and biochemical processes. [2+2]
- a. What are the steps to perform Sobol sensitivity analysis? [1]  
b. In Sobol sensitivity analysis, what does first order indices and second order indices signify? How can we verify certain parameter is significant based on sobol indices? [1+1]  
c. Differentiate between graphical and statistical method of validation. [1]  
d. How can we validate dynamic models? [1]
7. Explain any one Python function and its arguments used in each of the following models:  
a. Feedforward Multi-layered Neural Network  
b. Burger's Equation  
c. CSTR for complex reactions [3 x 1 = 3]

KATHMANDU UNIVERSITY  
End Semester Examination  
May/June, 2022

Marks scored:

Level : B.E.

Year : III

Exam Roll No.:

Time: 30 mins.

Course : CHEG 305  
Semester: II

F.M. : 10

Registration No.:

Date :

**SECTION "A"**  
[20Q × 0.5 = 10 marks]

Encircle the correct answer from the given choices.

1. Which one of the following models explicitly include the physical and chemical processes between the state variables?  
a. probabilistic      b. deterministic      c. empirical      d. mechanistic
  
2. What is the method to determine which variables, parameters, or other inputs have the most influence on the model output?  
a. uncertainty analysis      b. calibration  
c. validation      d. sensitivity analysis
  
3. A reactor contains a fluid that has elements having the same probability of leaving the reactor irrespective of the time they have spent in the reactor. Which type of model will be the most appropriate for the reactor?  
a. lumped model      b. stochastic model  
c. distributed model      d. population balance model
  
4. If an industrial area is contaminated by accidental release of a toxic fluid, what will you use to simulate the impact of the process immediately?  
a. lumped model      b. advection-diffusion model  
c. CSTR model      d. multi-layer perceptron model
  
5. In CFD modeling of a fluidized bed, what happens when the wave is traveling a distance that is less than  $dx$  over the time-step of  $\Delta t$ , where  $dx$  is the length of each mesh grid?  
a. it may become unstable      b. it may converge to the solution  
c. it fails the CFL condition      d. it slows down the time for the solution
  
6. For a given industry, what can be used to simulate the process and display the outcome in real time and a real environment?  
a. process simulator      b. conceptual model  
c. stochastic simulator      d. ANN model
  
7. Which type of equation is found in 1D steady-state distributed model?  
a. DAE      b. PDE      c. FDE      d. ODE
  
8. What is generally used to find solutions of models in design of industrial products?  
a. statistical analysis      b. optimization  
c. molecular simulation      d. CFD
  
9. Which type of model is based on cause and effect analysis?  
a. stochastic      b. empirical      c. deterministic      d. discrete

10. For diffusional mass transfer, which model is suitable at unsteady-state condition?  
a. Henry's law  
b. Fick's second law  
c. Burger's equation  
d. PFR model
11. A parameter such as friction factor appears on both sides of an equation. What is the best way to solve the equation?  
a. ode\_int  
b. FDM  
c. scikit\_learn  
d. Python root solver
12. Which model is the most suitable when selecting the cleanliness parameter in a washing machine?  
a. mechanistic model  
b. fuzzy model  
c. deterministic model  
d. dynamic model
13. Which software cannot handle molecular level simulations?  
a. Openfoam  
b. Fluent  
c. Polymath  
d. COMSOL
14. If you import sympy Python library and then run the command:  $y = \text{phi}.diff(x)$ , where phi is a sympy equation, what does "y" represent?  
a. partial derivative  
b. difference between phi and x  
c. total derivative  
d. finite difference
15. Read the following Python code to find concentration of a chemical:  $R = 8.2057E-5 \text{ # m}^3 \text{ atm / K / mol}$ ;  $\text{psO}_2 = 0.1 \text{ # atm}$ ;  $\text{MW}_{\text{SO}_2} = 64 \text{ # g/mol}$ ;  $T = 25+273 \text{ # K}$ . Which statement will be the next one to correctly calculate the concentration?  
a.  $\text{Ca}_0 = \text{psO}_2/\text{MW}_{\text{SO}_2} \cdot R/T/1000. \text{ # kg/m}^3$   
b.  $\text{Ca}_0 = \text{psO}_2 \cdot \text{MW}_{\text{SO}_2} \cdot R/T/1000. \text{ # kg/m}^3$   
c.  $\text{Ca}_0 = \text{psO}_2 \cdot \text{MW}_{\text{SO}_2} / R \cdot T / 1000. \text{ # kg/m}^3$   
d.  $\text{Ca}_0 = \text{psO}_2 \cdot \text{MW}_{\text{SO}_2} / R / T / 1000. \text{ # kg/m}^3$
16. Where is the assumption of a continuum acceptable?  
a. fluidized bed with fine particles  
b. slurry bubble column  
c. Gas-liquid interphase  
d. Solid-gas interphase
17. Which one of the following can be used to test the ANNs?  
a. null matrix  
b. confusion matrix  
c. triangular matrix  
d. diagonal matrix
18. Which one of the following activation functions gives only positive values?  
a. hyperbolic tangent sigmoid  
b. saturation  
c. log sigmoid  
d. arctangent
19. When do you adjust the weights associated with the connections between nodes in a neural network?  
a. training  
b. prediction  
c. splitting  
d. validation
20. Which model uses assumption of continuum for only the continuous phase and not for the dispersed phase in a multiphase system?  
a. Eulerian-Lagrangian  
b. Eulerian-Eulerian  
c. Fick's first law  
d. Fick's second law

KATHMANDU UNIVERSITY  
End Semester Examination  
May/June, 2022

Level : B.E.  
Year : III  
Time : 2 hrs. 30 mins.

Course : CHEG 305  
Semester : II  
F.M. : 40

SECTION "B"

Answer *ALL* questions. The data or information not given in the questions should be assumed properly.

1. What are the consequences of developing an unnecessarily complex models? Explain with any application in chemical engineering. Then provide solutions to make the models robust. [3+3]
2. What type of models can be used to simulate a CSTR and a PFR? Use the various model classifications that are applicable to them. [2+2]
3. Discuss the role of models in process simulation of adsorption and diffusion. [2+2]
4. How do you solve Burger's equations through numerical equations in CFD modeling? What is the role of CFL condition in CFD? [5+2]
5. State some of the ways to overcome over-fitting and under-fitting in ANN modeling. Then provide an example of the use of ANN in process modeling and monitoring. [3+3]
6. Describe the following concepts used in modeling and simulation of chemical processes:
  - a. Validation of dynamic models
  - b. Role of sensitivity in optimal process design
  - c. Modeling the multiphase systems having a dispersed phase[3×3=9]
7. What are the roles of the following Python functions in modeling and simulation? [4]
  - a. classification\_report
  - b. meshgrid
  - c. fsolve
  - d. StandardScaler

Level : B. E.  
Year : III

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Semester : II

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Time: 30 mins.

F.M. : 10

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Date

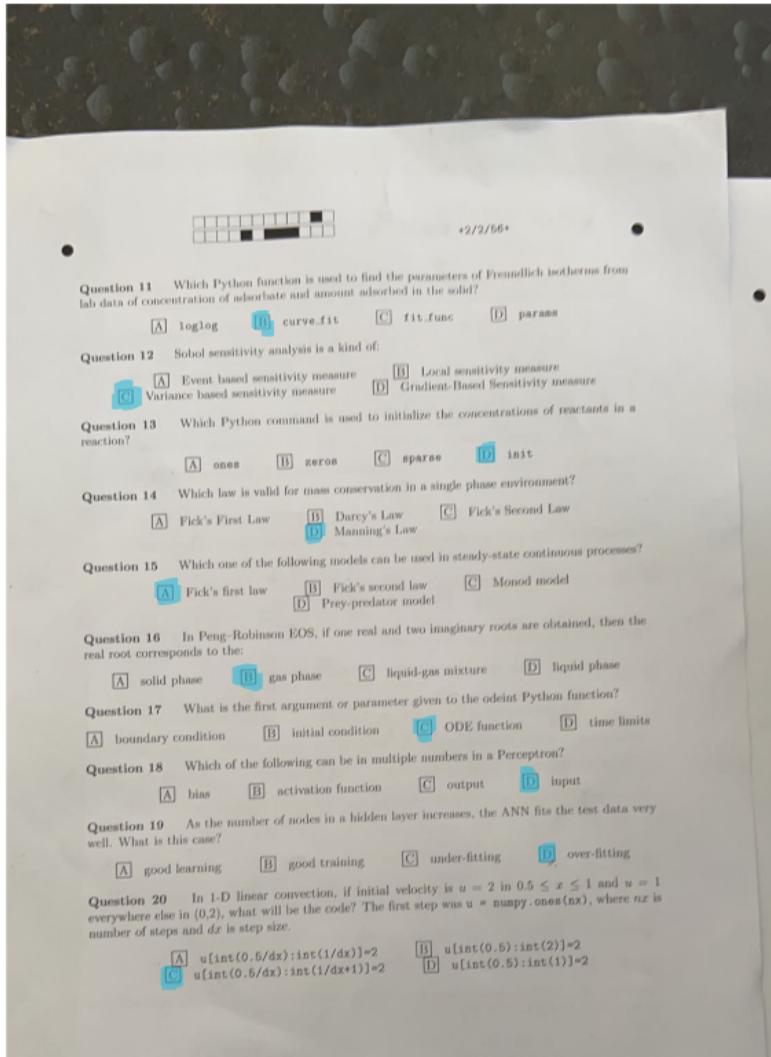
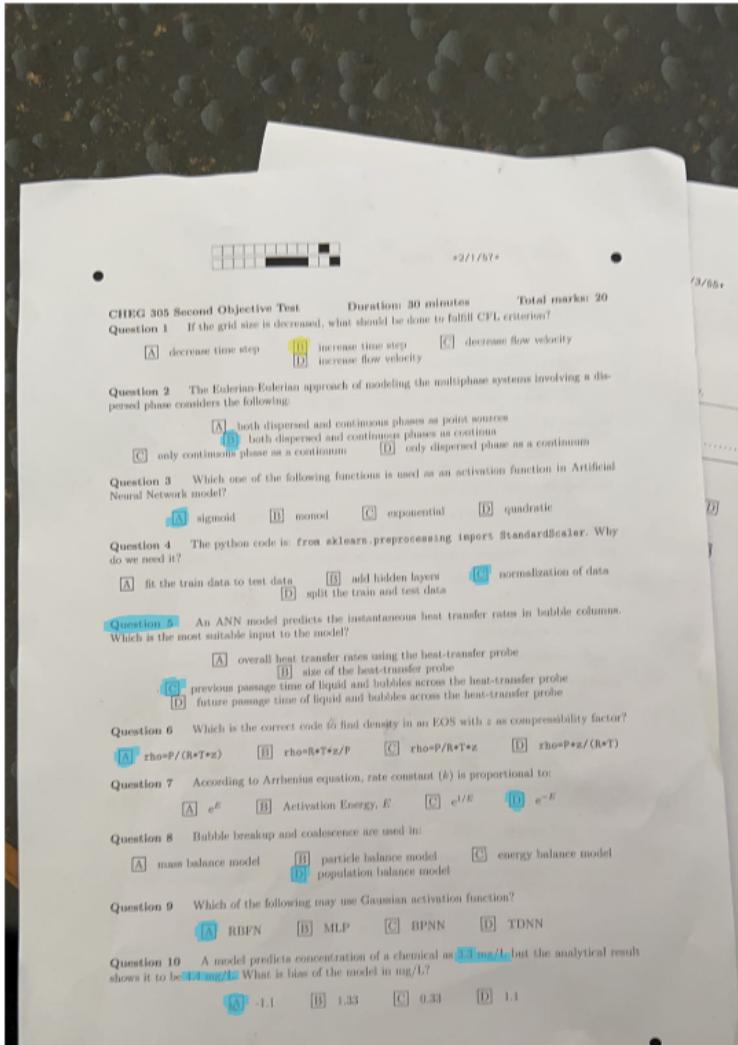
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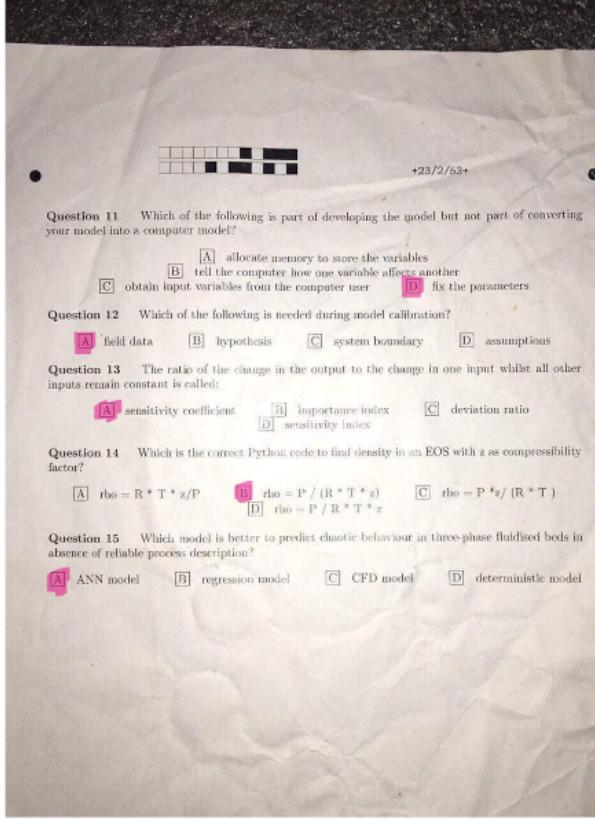
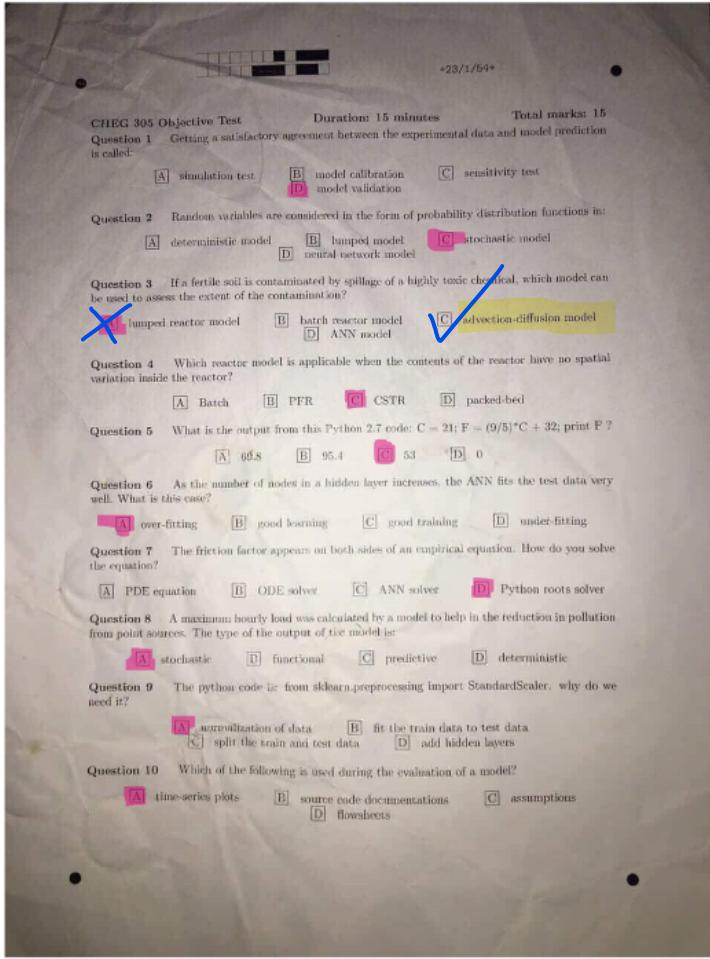
## **SECTION "A"**

**SECTION A**

Select the correct answer from the given choices. Attempt *ALL* the questions.

11. While solving Navier-Stokes equation numerically, what happens when the wave is traveling a distance which is greater than  $dx$  over the time-step of  $\Delta t$ , where  $dx$  is the length of each grid box?  
(a) it may become unstable  
(c) it satisfies the CFL condition  
(b) it converges to the solution slowly  
(d) it speeds up the convergence to the solution
12. If an area is contaminated by accidental release of a toxic liquid, which of the following models will be the most suitable to immediately predict the distribution of the liquid in the area?  
(a) lumped reactor model  
(c) advection-diffusion model  
(b) CSTR model  
(d) multi-layer perceptron model
13. In a multiphase system, if the assumption of continuum is made only for the continuous phase and the dispersed phase is treated by identifying each individual separately, which modeling approach is used?  
(a) Eulerian-CFD  
(c) Eulerian-Eulerian  
(b) Lagrangian-Lagrangian  
(d) Eulerian-Lagrangian
14. Which model is suitable for simulation of bubbles that are coalescing in a liquid system?  
(a) Navier-Stokes equation  
(c) mass and energy balance model  
(b) diffusion-convection model  
(d) population balance model
15. What is the use of lambda in the following Python code?  
`f = lambda z: z - (c*DAB/z)*math.log((1+xal)/(1+(z/(k*c))))`  
(a) create a variable  
(c) create an array  
(b) create a function  
(d) create a class
16. What will be the printed value of P from the following simple model?  
`from pint import UnitRegistry;  
ur=UnitRegistry()  
R=8.314*ur.joule/ur.kelvin/ur.mole;  
T=290.0*ur.kelvin  
n=2.0*ur.mole; V=22.4*ur.litre;  
P=n*R*T/V  
print P.to(ur.atmosphere)`  
(a) 215273.2  
(b) 2.1  
(c) 215.3  
(d) 31.2
17. In the following code, what will be the second element of the X array?  
`import numpy as np;  
X = np.linspace(0, 4.*np.pi, 4)`  
(a) 4.2  
(b) 12.6  
(c) 6.3  
(d) 8.4
18. While testing a model to be applied to simulate the fluidized bed, the output for various scenarios were measured when only one of the inputs was varied. Which one of the following is the most suitable for evaluating the model?  
(a) deviation ratio  
(c) importance index  
(b) sensitivity coefficient  
(d) sensitivity index
19. In a feed-forward back propagation neural network, what is propagated back into the network?  
(a) actual output  
(b) desired output  
(c) error in output  
(d) weight matrix
20. In a Python program to develop a model based on Artificial Neural Network, why do you import `MLPClassifier` from `sklearn.neural_network` package?  
(a) normalization of data  
(c) train the model  
(b) split the train and test data  
(d) classify output data





**CHEG 305 First Internal Exam****March 22, 2023****F.M. 15****Time: 1 hr**

1. Compare and contrast the lumped and distributed models with their key characteristics and examples of their applications. [2]
2. Briefly explain the steps to develop a CSTR model. [2]
3. Compare Peng-Robinson (PR) and Soave-Redlich-Kwong (SRK) EOSs for modeling Pressure, Volume and Temperature (PVT). [2]
4. Show how you can implement Burger's equations through numerical equations in CFD modeling. [4]

**OR**

The unsteady-state 1-D laminar flow is given by  $\frac{\partial V_x}{\partial t} = \nu \frac{\partial^2 V_x}{\partial y^2}$ , where  $\nu$  is the kinematic viscosity.

- (a) Propose a numerical finite difference method to find  $V_{i,j}$ , where  $i$  and  $j$  are indices for time and distance

- respectively. [2]
- (b) How do you check if the numerical solution to this problem is stable or not? [2]
  5. Briefly answer the following: [5]
- (a) What do you mean by "interpreted" and "dynamically typed" language?
  - (b) How do you convert a Python list into a Numpy array?
  - (c) What is the difference between `range` and `arange` functions?
  - (d) How do you change resolution of graphics that are plotted by `matplotlib` library?
  - (e) What are the required arguments of ODE solver `scipy.integrate.odeint`?

CHEG 305 2<sup>nd</sup> Internal Exam

May 24, 2023

Subj: 15

Obj: 10

1. (a) Show how the backpropagation neural network works using only a schematic diagram [2]  
 (b) Regarding chemical oxidation and coagulation, there is an online control of treatment of wastewater. A time-delayed back-propagation type ANN with a 7-4-1 structure was used for control of pH by addition of hydrogen peroxide. What can be the inputs to this model? [1]
2. In an urban region, the CO concentration was  $25000 \mu\text{g}/\text{m}^3$ . The mixing height during that time was 150 m, the wind was blowing at the speed of 0.7 m/s, and the background concentration of CO was  $3500 \mu\text{g}/\text{m}^3$ . The region is 6-km long and 3-km wide. Estimate the emission rate per unit area of CO for the region. [4]

A plant using coal emits 180 g/s of  $\text{SO}_2$  from a stack with height of 62 m. Plume rise is 14 m. Wind speed at the effective emission height is 6 m/s. Calculate the  $\text{SO}_2$  concentration at ground level 2.5 km downwind from the source at the plume centerline. Take the values of dispersion parameters  $\sigma_y = 115 \text{ m}$  and  $\sigma_z = 55 \text{ m}$ .

3. Batch tests were performed in the laboratory using solutions of phenol in water and particles of granular activated carbon. The equilibrium data at room temperature are shown in table below. Fit the Langmuir isotherm to the data. [4]

$c$ (kg phenol/ $\text{m}^3$ solution)	$q$ (kg phenol/kg carbon)	$c$ (kg phenol/ $\text{m}^3$ solution)	$q$ (kg phenol/kg carbon)
0.3220	0.150		0.0390
0.1170	0.122	0.0061	0.094
		0.0011	0.069
			0.055

4. A liquid level in a conical vessel is given by  $dx/dt = -kx^{1.5} + \alpha x^{-2}$  where  $\alpha = (3.14 R^2)/H^2$ ;  $k$ =valve constant.  $R$  and  $H$  are the known dimensions of the conical tank. Assume  $\alpha = 0.785$  and  $k = 0.117$ . The nominal level is  $x = 40 \text{ cm}$ . Under the steady state condition, derive the expression of sensitivity of  $x$  by  $u$  and find the value of normalized sensitivity. [3]

5. Write the population balance for well-mixed batch crystallization. [1]

**CHEG 305 First Internal Exam****April 30, 2024****F.M. 16****Time: 1 hr**

1. Describe the application of simulation in Chemical Engineering in any two key areas. [2]

2. Compare the stochastic and mechanistic models. [2]

3. Why is the SRK EOS called a cubic EOS? Why estimates obtained using an EOS may be inaccurate? [1+1]

4. Batch tests were performed using solutions of phenol in water and granular activated carbon. The equilibrium data at room temperature are shown below. Fit the Langmuir isotherm to the data. [4]

c (kg phenol/m <sup>3</sup> solution)	q (kg phenol/kg carbon)
0.322	0.15
0.117	0.122
0.039	0.094
0.0661	0.069
0.0011	0.055

5. Propose a numerical finite difference model for the unsteady diffusion in a slab. [4]

OR

The unsteady-state 1-D laminar flow is given by  $\frac{\partial V_i}{\partial t} = \nu \frac{\partial^2 V_i}{\partial x^2}$ , where  $\nu$  is the kinematic viscosity.

(a) Propose a numerical finite difference method to find  $V_{i,j}$ , where  $i$  and  $j$  are indices for time and distance respectively. [2]

(b) How do you check if the numerical solution to this problem is stable or not? [2]

6. Briefly answer the following: [2]

(a) Difference between range and arange.

(b) Arguments of ODE solver odeint.