# Abu Dhabi Polytechnic
# Meteorology Department

**MET-324 NWP and Numerical Analysis**

**Final Examination**
**Second Semester (2018-19)**

**2 Hours**

**Instructor: Dr. Nageswara Rao G.**

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| STUDENT NAME | |

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| STUDENT NUMBER | A | | | | | | | | |

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| CRN | 2 | 9 | 9 | 9 | DEPARTMENT | **MET** |

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**READ THESE INSTRUCTIONS CAREFULLY**

Write your *name*, *number*, *CRN* and department **clearly** in the boxes above.

Answer **all** questions.

Show **all** your working and use appropriate **units.** Otherwise, you may lose marks.

You may use a pencil for all your work.

Answers that are not **clearly readable,** if any, will not be marked.

| Section | Score |
|---|---|
| A | /18 |
| B | /14 |
| C | /26 |
| D | /12 |
| E | /16 |
| F | /14 |
| Total | /100 |

- **All mobile devices are not allowed during examination.**
- **Abu Dhabi Polytechnic considers cheating or attempting to cheat a serious offense that will result in disciplinary action taken against involved individuals.**

**Instructions**

1. **This paper consists of 6 Sections (A – F). Answer all the questions in each Section.**
2. **In each Section, for objective type questions, write the letter (a, b, c or d) of the correct answer and for descriptive questions, write your correct answers in the blank space provided below each question.**
3. **Give diagrams wherever necessary. Give all the steps in derivations.**

**Section-A (18 Points)** **CLO-1**

1. Numerical instability occurs due to _____ **(2)**
   a) truncation error
   b) large wind speeds
   c) large time step
   d) all the above
   e) none of the above

2. Time step for grid spacing of 10 km when the fastest wave speed in the model is 20 m/s_____ **(2)**
   a) 5 min
   b) 50 sec
   c) 500 sec
   d) none of the above

3. At a certain place, the gradient of temperature in $x$-direction is 0.3°C/50 km. If the present value of temperature at this place is 38°C and wind is westerly at 12 m/s, what would be the temperature after 3 hours, due to advection alone. **(6)**

A

4. Explain what implicit and explicit time differencing schemes are, giving examples. **(8)**

A.

**Section-B (14 Points)** **CLO-2**

1. The type of the following 2nd order linear partial differential equation is _____ **(2)**

$$\frac{\partial^2 \varphi}{\partial x^2} - 2\frac{\partial^2 \varphi}{\partial x \partial y} - \frac{\partial^2 \varphi}{\partial y^2} = 0$$

a) Elliptic
b) Hyperbolic
c) Parabolic
d) Poisson
e) none of the above

2. Solution of a parabolic partial differential equation requires _____ **(2)**
a) One initial condition at the initial time
b) One boundary condition at each point of the spatial boundary
c) One initial condition and one boundary condition at each point of the boundary
d) Many initial condition and many boundary conditions
e) None of the above

3. Drawbacks of global models are that they _____ **(2)**
a) require parameterization
b) have coarse resolution
c) CFL condition is violated near the poles
d) all the above
e) none of the above

4. What the Jacobian function represents? Give the three forms of the Jacobian, $J(\psi, \zeta)$. Write the finite difference expressions for these three Jacobians. Show the stencil of grid points used. **(8)**

A.

**Section-C (26 Points)** **CLO-3**

1a How do you use the Fourier series in spectral models? Give the Fourier series expansion for a generic function $A(x)$ in terms of sines and cosines. **(4)**

A.

1b Using Euler's formula for complex numbers, show that the above Fourier series expansion can be expressed in terms of exponential functions as: **(16)**

$$A(x) = \sum_{-\infty}^{\infty} c_n e^{inx}$$

Show all the steps in the derivation.

A.

4. What is a T-Number? Calculate the equivalent grid spacing for T511 spectral model (assume 3 grid points are sufficient to represent a wave and $1^o$ = 110 km). **(6)**

A.

**Section-D (12 Points)** **CLO-4**

1. The grids in which all the variables are specified at all the grid points are called _____ **(2)**
   a) staggered grids
   b) non-staggered grids
   c) Eliasson grids
   d) none of the above
2. What are the B-type and D-type (for even time step) Grids? Give the diagrams showing the distribution of the variables $u, v \; and \; \phi$ in these two types of grids. **(10)**

A.

**Section-E (16 Points)** **CLO-5**

1. For which of the following models, initialization is not necessary? _____ **(2)**
   a) Barotropic models
   b) Quasi Geostrophic models
   c) Spectral models
   d) None of the above

2. Suppose the observation of wind at a station is 18 m/s, while the first guess for the same location gives a 15 m/s wind with 6 m/s likely error. Also given that the error for wind observations is 3 m/s. Find the analysis wind speed. **(4)**

A.

3. Explain the concept of data assimilation with the help of a flow chart. **(10)**
Briefly describe a) objective analysis and b) initialization.

A.

**Section-F (14 Points)** **CLO-6**

1. To verify forecast *accuracy*, the forecast is to be compared against _____ **(2)**
a) a reference forecast
b) a corresponding observation
c) the climatological average
d) other model's forecast
e) none of the above

2. Schematically describe the concept of ensemble forecasting. What is its importance? **(6)**

A.

3. What is a contingency table? Showing in a diagram, describe the four categories (a, b, c and d) of the forecast-observation pairs in a contingency table. **(6)**

A.