

ASL410: Numerical Simulation of Atmosphere and Ocean

Major Examination

Time: 2 Hours

Aids Permitted: Calculator

The set of governing equations of the atmosphere is given in the Appendix

[Square brackets denote alternate phrasing or additional things that are not essential to the answer (but might partly compensate for points on other aspects of that question)]

Please put your Serial Number on the front page of the answer sheet

- Q.1: Between the forward difference and central difference which one is more accurate, and how? In the 1st model time step (marching from Initial condition to the next step), which method (forward or central difference) is used and why? [2x2.5 Marks]
- Q.3: How weather prediction is different from climate projection (explain from the view points of resolution, initial condition, boundary condition, hydrostatic approximation and physical forcing)? (5x1 Marks)
- Q.4: Which all terms of the primitive equations are not resolved by the atmospheric models? How do atmospheric models take those into account? (2x2.5 Marks)
- Q.6: If a model needs to be developed for the short term weather prediction over India, how are you going to tackle the following issues? {5x1 Marks}
- Which framework [*cubed sphere/lat-lon grid*] is preferable, and why? →
 - Should the hydrostatic assumption be taken (give the reasoning)? →
 - Is it necessary to have a scalable model (give the justification on both counts)? →
 - For what O(resolutions), the model should be developed and tuned? →
 - Will you use (non)uniform vertical resolution? (give the reasoning) →
- Q.7: Refer the appendix and answer the following questions {1x10=10 Marks}
- Is it possible to **analytically** solve the set of equations? Give the reasoning of your answer.
 - What are the sources of **non-linearities** in the governing set of equations? [Look at the terms which are non linear and name them on physical context]

- iii. Are the temperature and moisture equations **coupled** ? If yes, explain how ?
- iv. At global and annual scales [if you integrate a equation over the entire globe for at least a year], what will be the approximate magnitude (value) of **dq/dt**, If the incoming solar radiation remains same ?
- v. At global and annual scales, how do you compare **E with P** [are they equal, or $E > P$, or $P > E$, explain with reasoning in one or two lines] ?
- vi. Name the variables which are used as **initial conditions** ?
- vii. Specify the parameters those are used as **lower boundary conditions** ?
- viii. Specify the parameters which are used as **boundary conditions at the top of the model** ?
- ix. What is the CFL criterion ?
- x. In which direction Rossby waves propagate ?

Appendix

Wind Forecast Equations

1a.
$$\frac{\partial u}{\partial t} = -u \frac{\partial u}{\partial x} - v \frac{\partial u}{\partial y} - \omega \frac{\partial u}{\partial p} + fv - g \frac{\partial z}{\partial x} + F_x$$

1b.
$$\frac{\partial v}{\partial t} = -u \frac{\partial v}{\partial x} - v \frac{\partial v}{\partial y} - \omega \frac{\partial v}{\partial p} - fu - g \frac{\partial z}{\partial y} + F_y$$

Continuity Equation

2.
$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial \omega}{\partial p} = 0$$

Temperature Forecast Equation

3.
$$\frac{\partial T}{\partial t} = -u \frac{\partial T}{\partial x} - v \frac{\partial T}{\partial y} - \omega \left(\frac{\partial T}{\partial p} + \frac{RT}{c_p p} \right) + \frac{H}{\rho_p}$$

Moisture Forecast Equation

4.
$$\frac{\partial q}{\partial t} = -u \frac{\partial q}{\partial x} - v \frac{\partial q}{\partial y} - \omega \frac{\partial q}{\partial p} + E - P$$

Hydrostatic Equation

5.
$$\frac{\partial z}{\partial p} = -\frac{RT}{pg}$$