

INDIA METEOROLOGICAL DEPARTMENT

QUESTION BANK

OF

ADVANCED METEOROLOGICAL TRAINING

COURSE (AMTC)

SEMESTER-II EXAMINATION

ELECTIVE SUBJECT

BASED ON 173-181 BATCHES

(2013-2021)

**PAPER-V: PHYSICAL
OCEANOGRAPHY &
OCEAN-ATMOSPHERE
INTERACTION**

PART A

India Meteorological Department
Meteorological Training Institute
Advanced Meteorological Training Course

SEMESTER II (ELCETIVE SUJECT) Final Examination

PAPER-VI : Physical Oceanography & Ocean-Atmosphere Interaction

PART A

Q.1. Fill up the blanks

1. The depth of the ocean is measured using _____ and the deepest point in the world ocean is situated in _____.
2. Ocean subsurface temperature can be measured using _____ or _____.
3. The layer of the ocean below the surface layer in which the density increases rapidly with depth is called _____.
4. In the equatorial as well as subtropical area, the surface salinity depends upon the effects of _____ and _____.
5. For oceanic area, the density is expressed by a quantity _____ which is defined as _____.
6. The mean temperature of the world ocean is about _____ whereas the mean salinity is about _____.
7. The two major deep ocean sediments are _____ and _____.
8. Range of temperatures and salinities found in the open ocean----- and -----
9. Which among the following is the correct expression for surface wind stress?(a. $\tau = \rho C_d u$, b. $\tau = \rho C_d u^2$, c. $\tau = \rho C_d |u|u$, d. $\tau = \rho C_d u^{1/2}$)
10. _____ is the average height of the atmospheric boundary layer.
11. On a T-S diagram, a water body whose properties are represented by a point is called
12. The zone of rapid decrease of temperature with depth is called
13. In Langmuir circulations, the convergence streaks at the water surface is to the wind direction.
14. of the deep sea bottom originate from the remains of living organism.

15. For representing the geographical distributions of any physical property at a particular depth of ocean, is used as a display.
16. Range of temperatures and salinities found in the open ocean----- and -----
17. The zone between northern central water mass and Arctic water is called as _____ water mass.
18. Depth range of intermediate water masses is _____m
19. The thickness of the barrier layer is defined as_____
20. Character of Indian water mass not depends on.
21. Geographic position, b. On nature of current pattern, c. Interannual variations, d. It's separation from other region.
22. Arabian sea Monsoon Experiment (ARMEX-I) was conducted during the year
23. In general,..... percentage of radiation enters the sea.
24.causes the ocean near-surface wind speeds reduction.
25. Double-diffusive instabilities require an
26. When a thermocline exists in the ocean, we refer to the water as being.....
27. instabilities require an unstable temperature or salinity profile.
28. _____cause formation of Tsunamis.
29. Warm pool region of ocean having Sea Surface Temperature Greater than _____ Degree Celsius.
30. _____ satellite measurement used to measure Sea Level Heights.
31. Slow currents are observed _____sides of ocean.
32. Indian Summer monsoon Rainfall _____ during El Niño years.
33. The ocean mixed layer depth in the tropics and mid latitudes is m.
34. Enhanced horizontal advection of temperature the mixed layer temperature tendency.
35. On an average, $E - P$ is in the sub-tropical ocean.(a. < 0 b. > 0 c. $= 0$)
36. In ocean mixed layer, convective mixing happens during
37. length scale determines the size of the smallest possible eddies in the flow.
38. The Bay of Bengal salinity distribution is dominated by _____ whereas the Arabian salinity distribution is dominated by _____ process.
39. In Ekman transport the average direction of all turning water is at ____degrees from the wind direction.
40. Sea ice forms at a _____ temperature than ice in freshwater lakes.

Q.2. State whether following statements are true or false:

1. Coriolis force changes with latitude in f plane.
2. Western boundary current is strong compared to eastern boundary.
3. In ocean, change of density is more in horizontal compared to vertical.
4. Inertial current rotates clockwise in the northern hemisphere.
5. Vertical component of velocity is strong in the ocean compared to horizontal component of velocity.
6. Inertial current rotate clockwise in the Northern hemisphere and anti-clockwise in the Southern-hemisphere.
7. Upwelling at the equator can be explained using Ekman theory.
8. Evaporation minus precipitation is maximum at the equator.
9. Outgoing infrared thermal radiation always warms the ocean: True or False
10. Turbulent mixing in the surface layer is promoted by the interaction of wind and waves: True/False
11. The horizontal variability of the wind blowing on the sea surface leads to vertical velocities at the top of the Ekman layer. True/False
12. Mixed layer depth of tropical ocean is larger than mid-latitude ocean: True/False.
13. Outgoing infrared thermal radiation always warms the ocean: True / False
14. Turbulent mixing in the surface layer is promoted by the interaction of wind and waves: True/False
15. The horizontal variability of the wind blowing on the sea surface leads to vertical velocities at the top of the Ekman layer. True/False
16. Strong northerly winds prevail over the equatorial Pacific during El Nino events. True/False
17. Precipitation enhances in the western Indian Ocean during positive IOD events. True/False
18. The phase and group speed of Kelvin wave is different.
19. Yanai wave is a coastal wave.
20. Sea surface temperature is maximum at Bay of Bengal compared to Arabian Sea.
21. The time period associated with semidiurnal tide is 24 hour.
22. The frequency of gravity wave is high than Rossby wave.
23. Strong current is observed along western boundary compared to eastern.
24. Rossby wave is a coastally trapped wave: True/False.

25. High salinity is observed at Bay of Bengal compared to Arabian Sea.
26. The vast majority of water masses are formed at the surface of the sea in equatorial region and high latitudes. True/False.
27. During Atlantic Nino years equatorial western Atlantic is warmer than east? True/False
28. Chlorophyll strongly absorb radiation in the red and green wavelengths reflects yellow wavelengths: True/False
29. The Barrier-layer is the oceanic surface zone that responds the most quickly and directly to atmospheric fluxes. True/False
30. The intensity of incoming solar radiation is greatest for mid-latitudes in the hemisphere experiencing summer. True/False
31. The more intense (Hadley) cell has subsiding motion in the winter hemisphere: True/False
32. Outgoing infrared thermal radiation always warms the ocean: True or False
33. SST over the eastern Pacific is warm than western Pacific - True/False?
34. The intensity of incoming solar radiation is greatest for mid-latitudes in the hemisphere experiencing summer. True/False
35. Deserts are areas with minimum OLR. True/False
36. In Surface layer molecular transport and very vigorous turbulence are found. True/False
37. Earth, Moon, and Sun are lined up and work together During Spring Tides.
38. Deep currents caused by changes in density.
39. Evaporation process makes the ocean saltier and hence denser.
40. Kelvin waves are dispersive.
41. Potential temperature does not vary with height in the atmospheric mixed layer.
42. Density, salinity and temperature is uniform in the barrier layer.
43. Below the Taylor microscale the turbulent motions are subject to strong viscous forces and kinetic energy is dissipated into heat.
44. The Obukhov length is positive for unstable stratification.
45. Indian Ocean does not have coupled air-sea interaction. (True/False). Mention the reason.
46. Temperature has greater impact of density than salinity. (True/False). Mention the reason.

47. Cyclonic winds in the northern hemisphere can cause downwelling over the open ocean (True/False). Mention the reason.

Q.3. Answer the following.

1. Briefly explain the major features of surface temperatures and sub surface temperature distribution of the ocean.
2. And explain the different components of heat budget.
3. Brunt–Väisälä frequency or buoyancy frequency? Describe with formula.
4. Define barrier layer depth and write the importance.
5. Define counter currents.
6. Define Ekman current
7. Define IOD and explain its regional impacts.
8. Define mixed layer of the ocean.
9. Define pycnocline.
10. Define Reynolds Number and write significance.
11. Define Richardson number.
12. Define salinity. What are absolute salinity and practical salinity? Briefly mention the method of determination of the same.
13. Define the Von Karman Logarithmic law of the wall.
14. Define thermocline, pycnocline and halocline?
15. Define thermocline.
16. Define two processes which will deepen the mixed layer.
17. Derive and explain the heat budget equation of the ocean mixed layer.
18. Derive and explain the heat budget equation of the upper ocean.
19. Derive the expression for net rate of exchange of angular momentum between atmosphere and earth surface.
20. Derive the expression for net rate of exchange of angular momentum between atmosphere and earth surface.
21. Describe any two measurement techniques for the temperature profiles of ocean.
22. Describe any two mechanisms or theories of ENSO in detail with schematic diagram?
23. Describe Equatorial water mass.
24. Describe Intermediate water mass.
25. Describe methods how water masses are formed in the oceans?

26. Describe the major features of the ocean floor, starting from the land area close to the sea.
27. Describe the major ocean currents systems in the northern Indian Ocean during July (Summer) and January (Winter)
28. Describe the relative importance of surface heat and wind stress on mixing with appropriate diagrams. Define a measure of their relative contribution towards stability of water column.
29. Describe thermohaline circulation.
30. Draw a schematic diagram to show wind driven coastal upwelling and downwelling along east and west coast of India and explain the physics behind it. Discuss the possible reasons for the upwelling and downwelling at the equator and open ocean?
31. Draw the idealized profile of temperature in the atmospheric boundary layer and indicate its major parts.
32. Explain how the wind forcing in the central equatorial Indian ocean influence the coastal circulation around India
33. Explain Sverdrup balance for ocean circulation? What are the differences between Stommel and Munk solutions?
34. Explain the differences among Tide, Swell, Wind and Tsunami waves? Draw a schematic diagram to explain the forcing mechanism of tide?
35. Explain the important processes by which the surface wind forcing facilitate the mixing of the upper layers of the ocean.
36. Explain the major differences between atmospheric boundary layer and oceanic mixed layer.
37. Explain why the western boundary currents are stronger.
38. Give two factors affecting the latent heat flux.
39. High salinity is observed at Bay of Bengal compared to Arabian Sea. True/false with reason
40. How do we find thermocline depth of tropical ocean?
41. How does equatorial upwelling take place?
42. How does land runoff create hypoxic conditions in the coastal ocean?
43. How does ocean force atmospheric motion?
44. Mixed Layer depth in Bay of Bengal is deeper than Arabian Sea? True/False and why?

45. Mixed Layer depth in Bay of Bengal is deeper than Arabian Sea? True/False and why?
46. Name any two warm and cold currents.
47. Name any two warm currents and cold currents.
48. Name the instruments used for Ocean current measurements?
49. Name two western and eastern boundary currents in the northern hemisphere?
50. State a positive air sea feedback mechanism associated with El Nino.
51. State and explain the mechanism for generating downwelling and upwelling Kelvin waves in the equator.
52. State and explain the mixed layer temperature tendency equation.
53. State any two SST measurement techniques.
54. State some measures to reduce marine pollution.
55. State the differences between latent heat of evaporation and latent heat of condensation.
56. State the most important difference between entrainment and detrainment.
57. State three sources of marine pollution in detail.
58. State two factors which will deepen the mixed layer depth of the ocean.
59. State two impacts of global warming on coastal population.
60. State two sources of marine pollution.
61. Strong current is observed along western boundary compared to eastern. True/false with reason.
62. The upper layer of the ocean has temperature almost similar to that of the surface. What are the factors involved with that?
63. What are instabilities that generate turbulence in the ABL? and describe.
64. What are spring tides?
65. What are the assumptions made by Ekman? Write Ekman equations? Describe spiral with diagram? Write equation that relates the Ekman Pumping to wind stress.
66. What are the basic differences among internal wave, shallow water waves, deep water waves, capillary waves and gravity waves?
67. What are the different modes of graphical representation of oceanographic data?
68. What are the factors that influence the distribution of temperature and salinity at the ocean's surface?
69. What are the factors which influence the short-wave radiative flux?
70. What are the impacts of global warming on coastal population?

71. What are the kinds of instabilities that generate turbulence generation in the boundary layer and write properties of turbulence?
72. What are the types of water masses in the ocean and their depth range? Describe each water mass.
73. What are tides? Describe any one form of tidal power generation.
74. What causes Ocean mixing?
75. What determines the mixed layer depth?
76. What happens to local SST when a cyclone passes over the ocean.
77. What happens to the Indian Ocean SST when El Nino peaks in the Pacific Ocean.
78. What is ARGO?
79. What is ARGO?, How does it work.
80. What is Barrier Layer? What is importance?
81. What is Delayed Oscillator Theory?
82. What is depth range generally the Mediterranean Sea Water found in north Atlantic?
83. What is direction of Basil current?
84. What is Ekman Depth?
85. What is Ekman Number and explain?
86. What is Ekman Pumping and write equation? Explain Munk's solution for the gyre-scale circulation in an ocean basin?
87. What is ENSO?, give a brief description of the air sea interaction associated with El Nino.
88. What is hydrostatic, Boussinesq and geostrophy approximation? What is incompressible fluid? Derive continuity equation for incompressible fluid.
89. What is Indian Ocean Dipole? Explain with diagram.
90. What is mixed layer of the ocean? Define heat budget of the mixed layer?
91. What is Monin-Obukhov's similarity theory? Why this is called a "similarity" theory? Write the mathematical expression of the theory.
92. What is net heat flux (Q_0), explain and write equations each term?
93. What is Net heat flux and write equations for latent and sensible heat?
94. What is ocean mixed layer and write two criteria to find it.
95. What is ocean salinity budget equation and explain each term?
96. What is Recharge and discharge Theory?
97. What is Richardson number, write formula and criteria for stability?

98. What is Sverdrup transport? Explain why the western boundary currents in the ocean basins are stronger than the other current systems.
99. What is the angle of Ekman surface current and transport in the southern hemisphere?
100. What is the depth of Ekman layer?
101. What is the difference between practical salinity and absolute salinity?
102. What is the difference between Latent and Sensible heat flux?
103. What is the direction of net transport in Ekman layer? Where is the velocity maximum in Ekman layer?
104. What is the parking depth of Argo float?
105. What is thermohaline circulation and give possible reason of its generation?
106. What is thermohaline circulation?
107. What is topographic steering?, give an example.
108. What is upwelling and downwelling - Write with reference to sub-tropical gyres? Name upwelling regions in tropical Pacific and Indian Ocean regions?
109. What is upwelling and downwelling? How upwelling and downwelling is created over coastal and open oceans?
110. What is Viscous force?
111. What is western boundary intensification?
112. What is Yoshida Jet? Why this jet is formed? Write down zonal momentum equation associated with this jet?
113. Why does surface water sink in the north Atlantic region?
114. Write a note on difference between Arabian Sea and Bay of Bengal
115. Write a note on different ocean observation techniques.
116. Write a note on shortwave radiation with explanation using Wien's law and Stefan's law.
117. Write a note on snow ice albedo feedback.
118. Write a short note on the equatorial undercurrents in the Pacific Ocean and explain why they are confined to the equatorial region.
119. Write a short note on the general circulation of ocean surface currents.
120. Write differences between active and passive sensor?
121. Write differences between El Nino, La Nina and Normal conditions over Pacific both in atmosphere and Ocean (write in table form).
122. Write down ocean primitive equation of motion for ocean current, temperature, salinity, pressure and density.

123. Write note on [Sverdrup](#) and Stommel's theory of the general circulation of ocean currents?

124. Write note on the sensible heat flux with equation.

125. Write Ocean mixed layer temperature heat budget equation and describe each term?
Write equation for Brunt-Vaisala frequency?

126. Write Ocean mixed layer temperature heat budget equation and describe each term?

127. Write Sensor types used to measure SST, Ocean colour and Surface slope?

128. Write the differences between Rossby and Kelvin wave propagation?

129. Write the similarities and differences between ocean and atmospheric boundary layers.

130. Write upper ocean heat budget equation.

Q.4. Write short notes on following:

1. Specific volume anomaly and its application.
2. Latitudinal & vertical distribution of salinity