GX1510

OLLSCOIL NA hÉIREANN

NATIONAL UNIVERSITY OR IRELAND, GALWAY

SUMMER EXAMINATIONS, 1999

Fourth Year (Denominated B.Sc. Degree in Marine Science)

MR 406: Physical Oceanography

Professor A. Eleftheriou
and the internal examiners

Time allowed: *Three hours.*
Answer *five* questions.

1. Describe the theory of Stommel to explain the intensification of currents on the western side of ocean basins. Use sketches to explain the vorticity balance.

2. Describe the characteristics of deep-water formation and the resulting thermohaline circulation. How are the large-scale thermohaline and surface circulations related?

3. Explain these terms: planetary, relative and potential vorticity. Use the definitions and scaling arguments to show that the equatorial undercurrent remains tied to the regions around the equator and that currents have a tendency to flow along depth contours.

4. Define the terms internal Rossby radius and external Rossby radius, and explain what physical scaling the terms represent. What is the internal Rossby radius associated with a buoyant coastal flow of density 1032 kg m^{-3} in a shelf region of mean density 1035 kg m^{-3} and a depth of 100 m. Take f to be 1 x 10^{-4} rad s^{-1}.

5. What are the different responses of surface currents to wind-stress forces in deep and shallow water. Illustrate your answer by describing the currents set up in a rectangular basin which has shallow sides and a deep central region.

6. Explain the linkage between Ekman and geostrophic currents and why it is dificult to split up the two types of current. Use either the Ekman or Sverdrup theory for wind-driven currents to explain the equatorial current patterns.

7. What do each of these terms represent in the equation of motion below (x component only and some terms missing)?

$$du/dt + du/dx = (-1/\rho)dP/dx + fv + A_x d^2u/dz^2 + A_z d^2u/dz^2$$

Use scaling arguments to show that generally large scale ocean currents are principally in geostrophic balance and, using the continuity equation, that these large-scale horizontal currents are much greater than vertical currents.

8. Describe the different types of fronts that can occur in the coastal and shelf seas around Ireland and how they are formed.

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9. Using the theory of Ekman dynamics explain: (i) coastal upwelling; (ii) the reason that sea surfaces are higher at the centre of large ocean basins scale gyres; and (iii) equatorial upwelling. A north wind blows along a north-south aligned coast forming an eastern boundary, resulting in a wind stress of 0.2 N m^{-2} to the south. What is the mass flux (per unit area) in a direction perpendicular to the coast and mean upwelling velocity if the upwelling acts over a distance of 30 km from the coast. Take density of seawater to be 1000 kg m^{-3} for simplicity and f=1 x 10^{-4} rad s^{-1}. If the thermocline is 20 m, how long will it take before cooler water is seen at the ocean surface?