

CUET · GEOGRAPHY · CLASS XI · CODE 313

Movements of Ocean Water

CUET unit: Movements of Ocean Water

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Snapshot

- Ocean water moves in three main ways — **waves** (horizontal energy transfer), **tides** (vertical rise and fall of sea level), and **ocean currents** (continuous horizontal flow of huge water volumes in a definite direction) — together providing the physical basis for marine-geography questions in CUET.
- Each type has distinct driving forces: wind for waves; gravitational pull of the moon (dominant) and sun plus centrifugal force for tides; and a combination of solar heating, wind, gravity and the Coriolis force for ocean currents.
- Tidal types (semi-diurnal, diurnal, mixed; spring, neap) and positional terms (perigee, apogee, perihelion, aphelion) are high-frequency CUET targets because they are easily confused.
- Ocean currents are classified by depth (surface vs deep water — 10% vs 90% of ocean water) and temperature (warm vs cold), with specific rules about which coasts they appear on — a reliable source of NTA statement-based questions.
- The applied sections on the importance of tides and the effects of ocean currents on climate and fishing grounds link physical geography to human geography, a pattern NTA exploits.

Detailed Notes

2.1 Core concepts

Nature of ocean-water movement

- Ocean water is dynamic; its physical characteristics — temperature, salinity and density — and the external forces of the sun, moon and winds together influence its movement. **Horizontal motion** includes ocean currents and waves; **vertical motion** includes tides plus upwelling of cold water from the subsurface and the sinking of surface water (NCERT §Introduction, p. 108).
- Currents move water from one place to another; in waves, the water itself does not travel forward — only the wave train (the energy form) moves ahead. Tides are the **rise and fall of sea level twice a day** due to the attraction of the sun and moon (NCERT p. 108).

- Waves are **energy**, not water as such, moving across the ocean surface. Water particles only travel in a small circle as a wave passes — the wave form moves but the water particles do not progress. Wind provides energy to the waves and the energy is released on shorelines. The motion of surface water seldom affects the stagnant deep bottom water (NCERT p. 108).
- As a wave approaches the beach it slows down because of friction with the sea floor. When the **depth of water becomes less than half the wavelength**, the wave breaks. The **largest waves are found in the open oceans**, where they continue to grow as they absorb energy from the wind (NCERT p. 108).
- Most waves are caused by wind driving against water. A breeze of **two knots or less** generates small ripples that grow as wind speed increases, until white caps appear in breaking waves. Waves may travel **thousands of km** before rolling ashore, breaking and dissolving as surf (NCERT p. 108).
- A wave's size and shape reveal its origin — **steep waves** are young, locally generated; **slow, steady waves** originate from far-away places, possibly another hemisphere. Maximum wave height depends on (i) **strength of the wind**, (ii) **duration of the wind**, and (iii) the **fetch** — the area over which the wind blows in a single direction (NCERT p. 108).
- Waves travel because wind pushes the water body forward while gravity pulls the crests downward; the falling water pushes the former troughs upward, and the wave moves to a new position. Below the surface the motion of water is **circular** — particles are carried up and forward as the crest approaches, down and back as it passes (NCERT p. 109, Fig. 13.1).
- **Wave characteristics** (NCERT box, p. 109): **crest** (highest point) and **trough** (lowest); **wave height** = vertical distance from trough bottom to crest top; **wave amplitude** = half the wave height; **wavelength** = horizontal distance between two successive crests; **wave period** = time interval between two successive crests passing a fixed point; **wave speed** = rate at which the wave moves through water, measured in knots; **wave frequency** = number of waves passing a fixed point in one second.

Tides

- A **tide** is the periodical rise and fall of sea level, **once or twice a day**, mainly due to the **gravitational attraction of the moon and (to a lesser extent) the sun** (NCERT p. 109).
- **Surges** are water movements caused by **meteorological effects** — winds and atmospheric pressure changes; they are **not regular like tides** (NCERT p. 109).
- The study of tides is complex spatially and temporally because tides vary greatly in frequency, magnitude and height (NCERT p. 109).

- A third factor besides the moon's and sun's gravitational pull is **centrifugal force**, which acts to counter-balance gravity. Together, gravitational pull and centrifugal force create **two major tidal bulges** on the earth — one on the side facing the moon (where gravitational pull exceeds the centrifugal force, creating a net force toward the moon), and one on the opposite side (where centrifugal force dominates and creates a net force away from the moon) (NCERT p. 109, Fig. 13.2).
- The '**tide-generating**' force is the **difference** between the moon's gravitational pull and the centrifugal force. On the surface of the earth, the **horizontal tide-generating forces are more important than the vertical forces** in generating the tidal bulges (NCERT p. 109).
- Tidal bulges on **wide continental shelves** have greater height; when bulges hit **mid-oceanic islands**, they become low. **Funnel-shaped bays** and estuaries greatly magnify tidal magnitudes. **Tidal currents** are tides channelled between islands or into bays and estuaries (NCERT pp. 109–110).
- **Bay of Fundy, Canada** has the highest tides in the world — tidal bulge **15–16 m**. Two high and two low tides per ~24-hour day mean a tide comes in within about a six-hour period, rising about **240 cm per hour** ($1,440 \text{ cm} \div 6 \text{ h}$) (NCERT box, p. 110).

Types of tides

- **By frequency** — Semi-diurnal tide: most common; two high and two low tides per day, successive tides approximately equal in height. Diurnal tide: one high and one low tide per day, approximately equal in height. Mixed tide: variations in height; common along the **west coast of North America** and many islands of the Pacific Ocean (NCERT p. 110).
- **By sun-moon-earth positions** — Spring tides: sun, moon and earth in a straight line (syzygy); height of tide is higher; occur **twice a month** — at **full moon** and **new moon**. Neap tides: sun and moon at right angles to earth; forces partially counteract; occur about **7 days** after spring tides. The moon's attraction is more than **twice as strong as the sun's**, but is diminished by the counter-acting pull of the sun (NCERT p. 110).
- **Perigee** — once in a month, when the moon's orbit is closest to the earth, unusually high and low tides occur and the tidal range is **greater than normal**. **Apogee** — two weeks later, when the moon is farthest from the earth, its gravitational force is limited and tidal ranges are **less than average** (NCERT p. 110).
- **Perihelion** — when the earth is closest to the sun, around **3rd January** each year, tidal ranges are much greater, with unusually high and low tides. **Aphelion** — when the earth is farthest from the sun, around **4th July**, tidal ranges are much **less than average** (NCERT p. 110).
- **Ebb** — the time between high tide and low tide, when the water level is falling. **Flow / Flood** — the time between low tide and high tide, when the tide is rising (NCERT p. 110).

Importance of tides

- Tides are caused by accurately known earth–moon–sun positions and so can be **predicted well in advance**, helping navigators and fishermen plan their activities (NCERT p. 110).
- Tidal flows are of great importance in navigation; tidal heights matter especially at harbours near rivers and within estuaries having shallow 'bars' at the entrance, which would otherwise prevent ships and boats from entering the harbour (NCERT p. 110).
- Tides are helpful in **desilting sediments** and removing **polluted water from river estuaries** (NCERT p. 111).
- Tides are used to **generate electrical power** in Canada, France, Russia and China. In India, a **3 MW tidal power project at Durgaduani in the Sunderbans of West Bengal** is under way (NCERT p. 111).

Ocean currents

- Ocean currents are like river flow in oceans — a regular volume of water in a definite path and direction (NCERT p. 111).
- Currents are influenced by two types of forces: (i) **primary forces** that initiate the movement of water — heating by solar energy, wind, gravity and Coriolis force; (ii) **secondary forces** that influence how currents flow (NCERT p. 111).
- Solar heating causes equatorial ocean water to expand, making it about **8 cm higher than in middle latitudes** — a slight gradient down which water tends to flow. Wind blowing on the surface pushes water; friction between wind and water surface affects the movement; gravity pulls water down the pile; the **Coriolis force** deflects water to the **right in the Northern Hemisphere and to the left in the Southern Hemisphere**. These large accumulations of water and the flow around them are called **Gyres** — large circular currents in all ocean basins (NCERT p. 111).
- Differences in water density affect vertical mobility — water with **high salinity is denser** than low-salinity water, and **cold water is denser** than warm water. Denser water sinks; lighter water rises. Cold-water currents form when cold polar water sinks and slowly moves towards the equator; warm-water currents travel from the equator polewards along the surface to replace the sinking cold water (NCERT p. 111).

Characteristics of ocean currents (NCERT box, p. 111)

- Currents are referred to by their "drift". They are strongest near the surface — up to **5 knots** — and weaker at depth (generally **less than 0.5 knots**). Drift is measured in knots.

Types of ocean currents

- **By depth** — Surface currents: upper **~400 m** of the ocean; about **10%** of ocean water. Deep-water currents: remaining **90%**; move around ocean basins due to

density and gravity variations; sink in deep ocean basins at **high latitudes** where temperatures are cold enough for density to increase (NCERT p. 111).

- **By temperature** — Cold currents: bring cold water into warm-water areas; usually found on the **west coasts of continents in the low and middle latitudes (both hemispheres)** and on the **east coasts in higher latitudes of the Northern Hemisphere**. Warm currents: bring warm water into cold-water areas; usually observed on the **east coasts of continents in the low and middle latitudes (both hemispheres)**, and in the Northern Hemisphere also on the **west coasts of continents at high latitudes** (NCERT p. 111).
- Major currents are greatly influenced by prevailing winds and Coriolis force. Oceanic circulation roughly corresponds to atmospheric circulation — **anticyclonic in middle latitudes** (more pronounced in the southern hemisphere), **cyclonic at higher latitudes**, and **monsoon-influenced** in regions of pronounced monsoonal flow. Warm currents from low latitudes move to the **right in the Northern Hemisphere** and to their **left in the Southern Hemisphere** because of the Coriolis force (NCERT pp. 111–112).
- Oceanic circulation transports heat from one latitude belt to another, much like atmospheric circulation — cold Arctic and Antarctic waters move toward warmer tropical and equatorial regions, while warm waters of the lower latitudes move polewards (NCERT p. 112).

Effects of ocean currents

- **West coasts in tropical and subtropical latitudes (except near the equator)** are bordered by **cool waters** — low average temperatures, narrow diurnal and annual ranges, fog, generally **arid** conditions.
- **West coasts in middle and higher latitudes** are bordered by **warm waters** — a distinct **marine climate** with cool summers and mild winters, narrow annual temperature range.
- **East coasts in tropical and subtropical latitudes** with parallel warm currents have **warm and rainy** climates; they lie in the western margins of subtropical anti-cyclones.
- The **mixing of warm and cold currents** replenishes oxygen and favours the growth of plankton — the primary food of fish — so the world's **best fishing grounds** lie mainly in these mixing zones (NCERT p. 112).

2.2 Definitions to memorise

Term	Definition	Page
Wave	Energy moving across the ocean surface; water particles trace a circle but do not progress with the wave	108
Fetch	Area over which the wind blows in a single direction; one of three determinants of maximum wave height	108

Term	Definition	Page
Wave height	Vertical distance from the bottom of a trough to the top of a crest	109
Wave amplitude	One-half of the wave height	109
Wavelength	Horizontal distance between two successive crests	109
Wave period	Time interval between two successive wave crests/troughs passing a fixed point	109
Wave speed	Rate at which a wave moves through water, measured in knots	109
Wave frequency	Number of waves passing a given point per second	109
Tide	Periodical rise and fall of sea level, once or twice a day, due mainly to gravitational attraction of the moon (and to a lesser extent the sun)	109
Surge	Water movement caused by meteorological effects (winds, atmospheric pressure); not regular like tides	109
Tide-generating force	Difference between gravitational attraction of the moon and the centrifugal force	109
Tidal current	Tide channelled between islands or into bays/estuaries	109
Semi-diurnal tide	Two high tides and two low tides each day, successive tides approximately equal in height	110
Diurnal tide	One high and one low tide per day, of approximately equal height	110
Mixed tide	Tides with variations in height; common on the west coast of North America and many Pacific islands	110
Spring tide	Sun, moon and earth in a straight line; highest tides; occur twice a month at full moon and new moon	110
Neap tide	Sun and moon at right angles to earth; forces partially cancel; occurs ~7 days after spring tide	110
Perigee	Point in the moon's orbit closest to the earth — tidal range greater than normal	110
Apogee	Point in the moon's orbit farthest from the earth — tidal range less than average	110
Perihelion	Point in earth's orbit closest to the sun (~3 January) — tidal range much greater	110
Aphelion	Point in earth's orbit farthest from the sun (~4 July) — tidal range much less	110
Ebb	Time between high tide and low tide when water level is falling	110
Flow / Flood	Time between low tide and high tide when the tide is rising	110
Gyre	Large circular ocean-current system formed by accumulations of water deflected by the Coriolis force	111

Term	Definition	Page
Drift	Speed of an ocean current, measured in knots	111

2.3 Diagrams / processes to remember

- **Figure 13.1 (p. 109)** — Motion of waves and water molecules. Shows the wave travelling to the right, with crests falling and troughs rising; below the surface the water molecules trace **circular paths**, carried up and forward as the wave approaches and down and back as it passes. Anchors the central NCERT point that **energy travels forward but the water does not**.
- **Figure 13.2 (p. 109)** — Relation between gravitational forces and tides. Three-panel diagram: (1) gravitational force alone produces one bulge **toward the moon**; (2) centrifugal force alone produces a bulge **on the opposite side**; (3) their combined effect produces **two resultant tidal bulges** with the sun, moon and earth aligned. Demonstrates why both sides of the earth simultaneously experience high tide.
- **Figure 13.3 (p. 112)** — Major currents in the Pacific, Atlantic and Indian oceans. Map showing named warm and cold currents — **Gulf Stream, North Atlantic Drift, Labrador, Canaries, Brazilian, Falkland, Benguela** (Atlantic); **Alaska, California, North & South Equatorial, Eq. Counter, Kuroshio, Oyashio, N. Pacific Drift, Humboldt (Peru), West Wind Drift** (Pacific); **Agulhas, West Australian** (Indian). Students should be able to identify direction and warm/cold classification.
- **Process flow — wave generation and breaking:** wind ≥ 2 knots \rightarrow ripples \rightarrow growth as energy is absorbed \rightarrow travel across open ocean \rightarrow friction with sea floor near shore \rightarrow wave slows \rightarrow at depth $< \frac{1}{2}$ wavelength, wave breaks \rightarrow surf.
- **Process flow — spring/neap cycle:** full or new moon (sun–earth–moon aligned) \rightarrow spring tide (highest) \rightarrow ~7 days \rightarrow quadrature (sun–moon at right angles) \rightarrow neap tide (lowest range) \rightarrow repeat twice a month.
- **Process flow — ocean current formation:** solar heating raises equatorial water by ~8 cm \rightarrow wind shears the surface \rightarrow gravity pulls water down the gradient \rightarrow Coriolis deflects (right in NH, left in SH) \rightarrow circular gyres in each basin \rightarrow density gradients (cold + saline sinks at poles) drive the deep-water leg.

2.5 Key data table (NCERT figures from this chapter)

#	Item	NCERT figure	Page
1	Breeze speed at which ripples begin	2 knots or less	108
2	Wave-breaking depth	$<$ half the wavelength	108
3	Three determinants of maximum wave height	Wind strength, wind duration, fetch	108
4	Bay of Fundy tidal bulge	15–16 m	110

#	Item	NCERT figure	Page
5	Bay of Fundy approximate hourly tidal rise	~240 cm/hour	110
6	Spring tides per month	Twice (full moon + new moon)	110
7	Interval between spring and neap tides	~7 days	110
8	Date of perihelion (earth closest to sun)	~3 January	110
9	Date of aphelion (earth farthest from sun)	~4 July	110
10	Moon's attraction vs sun's	More than twice as strong	110
11	Indian tidal power project	3 MW, Durgaduani, Sunderbans, West Bengal	111
12	Equatorial sea-level excess over mid-latitudes	~8 cm	111
13	Surface currents — depth & share	Upper 400 m; ~10% of ocean water	111
14	Deep-water currents — share	~90% of ocean water	111
15	Typical surface-current speed	Up to 5 knots; deep < 0.5 knots	111

2.4 Common confusions / NTA trap points

- **Perigee vs Perihelion:** Perigee is the moon's closest approach to earth; Perihelion is earth's closest approach to the sun (around 3rd January). NTA frequently swaps these terms.
- **Apogee vs Aphelion:** Mirror confusion — Apogee is the moon farthest from earth (reduces tidal range); Aphelion is earth farthest from the sun on ~4 July (also reduces tidal range). Both reduce range but involve different bodies.
- **Spring tides** do **not** mean the spring season — they occur twice every lunar month at full moon and new moon, in every month of the year.
- **Neap tides** occur **~7 days** after spring tides, with sun and moon at **right angles** (quadrature), not in a straight line.
- **Cold currents lie on the west coasts and warm currents on the east coasts** of continents in the low and middle latitudes of both hemispheres — students often reverse this. Remember Humboldt (cold, west coast of South America) and Gulf Stream (warm, east coast of North America).
- In the **Northern Hemisphere only**, cold currents are also found on east coasts in **higher latitudes** (e.g., Labrador), and warm currents on west coasts at high latitudes (e.g., North Atlantic Drift extension).
- **Waves carry energy, not water** — a frequent option claims water particles travel along with the wave; this is wrong. Particles trace circles in place.

- **Surface vs deep water current shares:** surface \approx 10%, deep \approx 90% — students often invert these.
- **Surges are not tides** — surges are caused by meteorology (winds, atmospheric pressure) and are irregular; tides are astronomical and predictable.
- The **moon's gravitational pull is more than twice as strong as the sun's** — NCERT emphasises this; "the sun's pull is stronger" is always wrong.
- **Horizontal tide-generating forces > vertical** in producing tidal bulges — NCERT explicitly states this; reversing it is a trap.
- **Tidal power project** in India is **3 MW at Durgaduani, Sunderbans, West Bengal** — not Gulf of Khambhat or Gulf of Kachchh (those are proposed, not the figure NCERT gives).

Practice MCQs

PYQ Alignment

This chapter is a reliable source of CUET Geography questions, with **tidal terminology** (spring/neap, perigee/apogee, perihelion/aphelion, semi-diurnal/diurnal), **wave characteristics**, and **ocean current classification** (warm vs cold; surface vs deep water) appearing regularly. Statement-based and match-the-column formats are particularly common for this chapter's content. For drill sets and previous-year analyses see </pyq/geography>.