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1. Air Masses — Definition & Classification

Air Mass: A large body of air covering an area of thousands of square kilometres in which the horizontal and vertical distribution of temperature (density) and moisture are nearly uniform.

Air masses move with the wind and carry their properties. Weather associated with air masses depends on their properties and interplay with other air masses. Characteristics differ with origin and travel — during travel they get modified.

Source Region: An air mass forms when a large body of air stagnates over a region having fairly uniform temperature and moisture content for a long period. High pressure areas with light winds are the most suitable source regions. Main source regions = **poles** and **sub-tropical highs**.

Classification: Temperature (density) and humidity are the two main characteristics of air masses.

- Temperature characteristics determined by latitude zone of the source region
- Moisture characteristics determined by whether source region is continental or maritime

→ Polar/Tropical (temperature) × Continental/Maritime (moisture) = four basic types, plus Arctic and Equatorial.

Air Mass	Symbol	Place of Origin	Properties
Arctic	A	Polar regions	Extreme low temp, low humidity in winters; humidity increases in summers
Polar Continental	Pc	Sub-polar continental areas	Low temperatures which increase with movement towards lower latitude; low humidity
Polar Maritime	Pm	Sub-polar and Arctic oceanic areas	Low temperatures which increase with movement towards lower latitude; high humidity
Tropical Continental	Tc	Subtropical High Pressure land area	High temperatures, low humidity
Tropical Maritime	Tm	Southern border of oceanic sub-tropical highs	Moderately high temperatures, high humidity
Equatorial Maritime	Em	Equatorial and tropical seas	High temperatures, high humidity (SW Monsoon is Em air mass)

 **Memory aid:** Continental = dry (land source). Maritime = moist (sea source). Polar = cold. Tropical = warm. Equatorial = hot & humid. The SW Monsoon air mass = **Em (Equatorial Maritime)**.

2. Air Masses over Indian Sub-Continent

Tropical Maritime (Tm)

Originates in subtropical highs of the north Pacific Ocean; arrives over India during monsoon season after travel over SE Asian countries. Characterised by:

- High temperature, high relative humidity, high dew point
- Excellent visibility
- Fairly high diurnal range of temperature
- Cumuliform clouds causing showers or thunderstorms in some places

Tropical Continental (Tc)

Most common air mass over India, particularly in **winter**. Originates in the Siberian high; moves over India as a cold dry current. Associated with fair weather and **poor visibility** conditions.

Equatorial Maritime (Em)

Originates over the Indian Ocean; long travel over water. Prevails over India to the south of **25°N** during monsoon season. High humidity → sultry weather. Visibility is good except in showers. Diurnal range of temperature is small.

Seasonal Air Mass Distribution over India

Season	North/NW India	South/Central India	NE India / Himalayan ranges
Winter	Tc (dominant); incursion of Pc after WD passage → Cold Waves	Occasional Tm from south of equator (= Em / equatorial maritime air)	WDs draw Tm from Arabian Sea and Bay of Bengal
Summer / Monsoon	Tc air	Em air (Monsoon Trough established over Gangetic plains by June)	Modified Tm air from north Pacific (different from Em)

3. Fronts — Definition & Terminology

Front: A narrow zone of transition between two air masses of contrasting densities. The contrasting densities are due to different temperatures and humidity of the air masses. At a front there is change in temperature, wind, clouding, and precipitation.

Frontal Surface: The sloping surface along which the two air masses exist and meet; the place where this frontal surface meets the ground is the front.

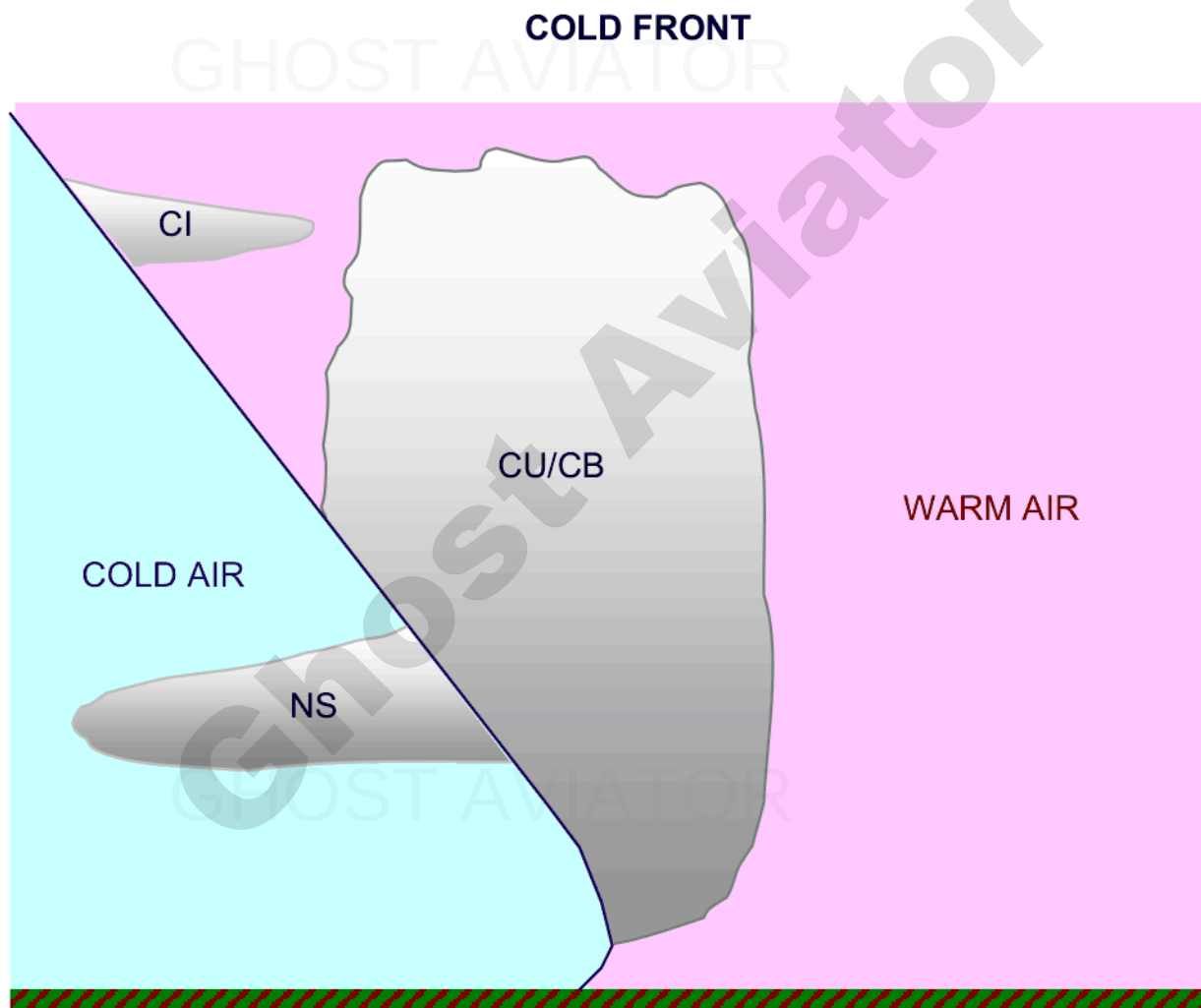
Frontogenesis: Formation or strengthening of a front. Occurs only when there is a significant density contrast between two air masses.

Frontolysis: Weakening of front with time and dissipation of frontal weather. If density contrast is insignificant, the front passes off unnoticed (except for change in winds).

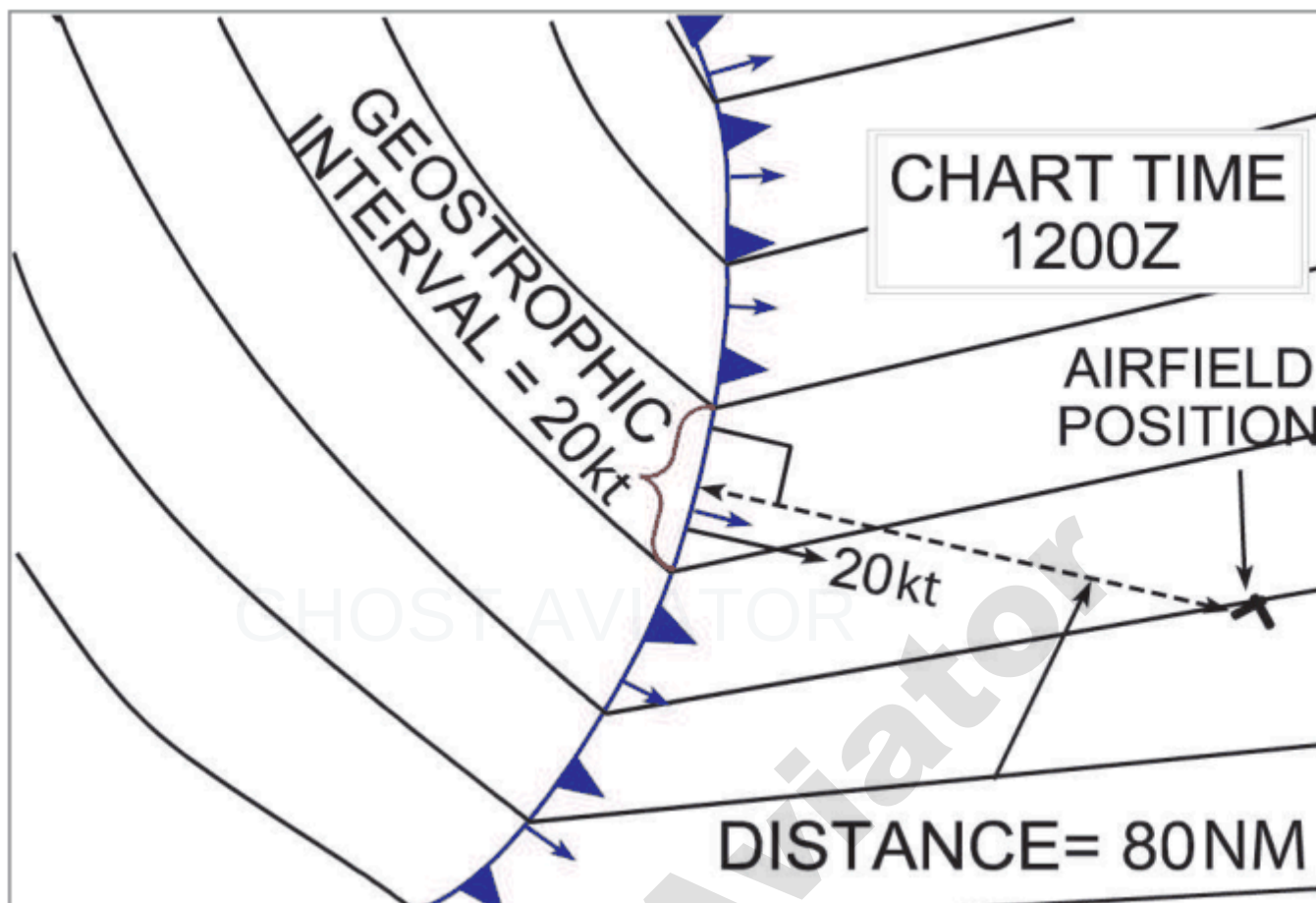
4. Cold Front

A demarcation zone between **cold air overtaking warm air**. Cold air provides a wedge on which warm air glides. Most cold fronts are associated with **CU and CB clouds**.

Average slope of cold front: **1:50** (becomes shallower at higher levels).



Cold front cross-section



Cold front speed

Feature	Kata Type Cold Front	Ana Type Cold Front
Slope	1:120 (shallow)	1:50 (steep)
Speed	About 20 kt	Exceeds 30 kt
Warm Air Motion	General sinking (kata = katabatic) at high levels	Rising (ana = anabatic) at high levels — instability
Clouds	ST, NS, AS and CU, CB (widespread stratiform)	CU, CB (convective; CB clouds dominate)
Precipitation	Widespread; showery in advance & just behind surface front (due to CB); NS and AS behind	Violent TS, hail, short-duration showers; confined to 100–150 km
Special Feature	Sometimes moves very fast → line squall at 100–300 km ahead of front	Behind the front: CU, CB clouds and isolated showers. Sky clears rapidly.

flowchart LR

A[Cold Air\nAdvancing] -->|Wedge under warm air| B[Warm Air Lifted]

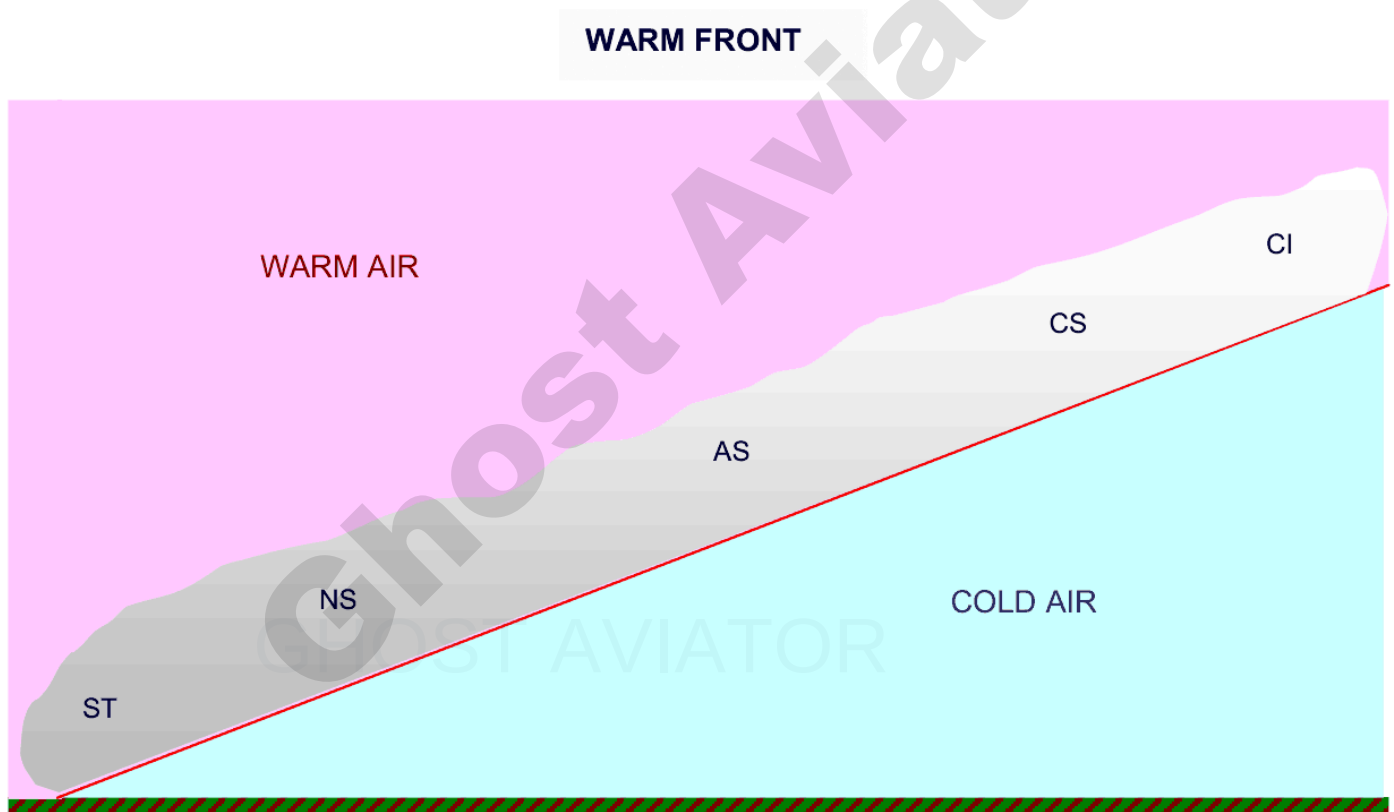
B --> C{Warm air motion?}

C -->|Sinking kata| D[Kata Cold Front\nSlope 1:120, 20kt\nStratiform clouds\nLine squall 100-300km ahead]

C -->|Rising ana| E[Ana Cold Front\nSlope 1:50, >30kt\nCB dominant\nViolent TS, hail, 100-150km wide]

5. Warm Front

A demarcation zone between **warm air overtaking cold air**. Slope: **1:150 to 1:180**. Speed: about **10-15 kt**. If warm air is stable and sinks at higher levels = Kata Type warm front. If warm air is unstable = Ana Type warm front.



Warm front cross-section

Feature	Kata Type Warm Front	Ana Type Warm Front
Approach (1000 km ahead)	Ci, Cs	Ci, Cs
400–500 km from front	NS, AS clouds appear	CU and CB embedded in stratiform
Just ahead of front	Drizzle, low stratus, sometimes frontal fog	Drizzle from ST clouds; brief spells of heavy precipitation
After passage	Fog dissipates; sky partially clear; warmer and humid	Fog dissipates; skies practically clear

🧠 **Warm Front sequence (Kata):** 1000 km: Ci,Cs → 400-500 km: NS,AS → Just ahead: Frontal Fog + Drizzle → After: Warmer & Humid.

Cloud sequence ahead of warm front: **Ci → Cs → As → Ns → St → Front**

6. Occluded Front

A cold front normally moves at **twice the speed** of a warm front. An occluded front forms when a cold front catches up with a warm front.

Feature	Cold Occlusion	Warm Occlusion
Condition	Air mass of advancing cold front is COLDER than the cool air mass of the warm front	Air mass behind advancing cold front is LESS COLD (COOL) than cold air mass of warm front ahead
Process	Advancing cold front undercuts and lifts both warm and cool air masses of the warm front	Advancing cold front overrides the warm front ahead
Initial weather	Warm front type; during passage = showery (cold front) weather	Similar to warm front throughout
Season	Common in summers	Occurs in winters , less common

flowchart TD

A[Cold Front moves at TWICE speed of Warm Front] --> B[Cold Front catches up with Warm Front]

B --> C[OCCLUDED FRONT forms]

C --> D{Cold air behind vs ahead?}

D -->|Behind air COLDER than cool air ahead| E[COLD OCCLUSION Undercuts both air masses Common in SUMMERS]

D -->|Behind air LESS COLD than cold air ahead| F[WARM OCCLUSION Overrides warm front Occurs in WINTERS]

7. Stationary Front & World Fronts

Stationary Front: Exhibits almost no movement. Two contrasting air masses on either side. Winds on either side blow parallel to the front but in **opposite directions**. The Polar Front is an example of a stationary front.

Front	Location	Description
Polar Front	~ 60°N/S	Transition zone between polar easterlies and mid-latitude westerlies. Not continuous; active only in segments.
Arctic Front	North of polar front	Boundary between arctic and polar air masses. Often displaced southwards into temperate latitudes in winters.
Mediterranean Front	Over Mediterranean Sea	Boundary between Pc air from Europe and Tc air from North Africa. Extends roughly W to E over Mediterranean in winter.

8. Fronts in India

India is not affected by fronts, **except in extreme NW India**. The Western Disturbances which affect NW India are of frontal origin. However, when they reach India they are already in the **occluded stage**.

9. Western Disturbances (WD)

Western Disturbances: Lows or troughs which move from W to E, north of **20°N**, and cause weather. When the low has two or more closed isobars at **2 hPa** interval, it is termed a **Western Depression**. Troughs above **500 hPa** level = **Troughs in Westerlies**.

Origin: Mediterranean Sea, Caspian Sea, and Black Sea; move eastwards across north India. WDs belong to the **extra-tropical cyclone family**. Over India they are in the occluded state, causing warm/cold front type cloudiness and weather. Intensify over NW India due to orography and moisture feed from Arabian Sea.

Induced Low and Induced Cyclonic Circulation: Under the influence of a WD, sometimes a low develops to the south of the system (*induced low*), and sometimes a cyclonic circulation develops to the south (*induced cyclonic circulation*).

Parameter	Value / Detail
Frequency in winters	5–7 per month
Monsoon months	NIL (decreases to nil)
Reappear	From October onwards
Rate of movement	About 250–300 km per day
Track	Pakistan/Rajasthan → NE towards W Himalayas; some glide along foot hills towards E; few move towards UP, MP, Bihar, then NE India
Weather affected area (~50% cases)	J&K, HP, Punjab, Haryana, Uttarakhand, Sikkim, Bhutan, Arunachal
Max clouding and precipitation zone	Always along the foot hills
After WD passage	Widespread fog and cold waves are common; fog lifts by forenoon (may persist for a few days)

⚠ Aviation Hazards from WD:

- During approach/passage: low clouds, poor visibility, rain, TS, hail, icing
- After passage: widespread fog
- Pre-monsoon WDs: widespread dust haze and dust storms over NW India; TS over northern plains

Trough in Westerlies: A series of upper-level troughs; westerlies keep moving W to E. Large amplitude troughs → upper air divergence ahead → enhances weather activity considerably. Severe TS/DS, Norwesters, and heavy rains are associated with these troughs.

flowchart LR

A[WD originates\nMediterranean/Caspian/Black Sea] --> B[Moves W→E\nNorth of 20°N\n250-300 km/day]

B --> C[Reaches India\nin Occluded Stage]

C --> D[NW India\nJandK, HP, Punjab\nHaryana, Uttarakhand]

C --> E[Intensifies due to\nHimalayas + Arabian Sea moisture]

E --> F[Weather: clouds, rain, snow,\nhail, icing, TS, fog]

C --> G[Induced Low\nto south of WD system]

10. Quick Revision Summary

⚡ AMBER Quick Revision — Air Masses, Fronts & WD

- **6 Air Mass types:** A (Arctic), Pc, Pm, Tc, Tm, Em | SW Monsoon = Em
- **Most common in India (winter):** Tc (Siberian High → India, cold dry, poor visibility)
- **Monsoon:** Em over India south of 25°N; Tc over NW India; Modified Tm over NE India
- **Front:** Narrow transition zone between contrasting air masses | At front: change in temp, wind, cloud, precipitation
- **Frontogenesis** = formation | **Frontolysis** = weakening
- **Cold Front slope:** 1:50 | **Warm Front slope:** 1:150 to 1:180
- **Kata Cold Front:** 1:120, ~20 kt, stratiform, line squall 100–300 km ahead | **Ana Cold Front:** 1:50, >30 kt, CB/TS, 100–150 km wide
- **Warm front clouds (1000→0 km):** Ci → Cs → As → Ns → St → Frontal fog
- **Cold front moves at TWICE the speed of warm front**
- **Cold Occlusion:** Undercuts both air masses; summers | **Warm Occlusion:** Overrides warm front; winters
- **Polar Front:** ~60°; not continuous | **Stationary front:** Winds parallel but opposite directions
- **India:** Not affected by fronts except extreme NW India; WDs arrive in occluded stage
- **WD:** Extra-tropical cyclone; Med/Caspian/Black Sea origin; 5–7/month in winter; NIL in monsoon
- **WD movement:** 250–300 km/day; Pakistan → NE towards W Himalayas
- **WD weather:** Max clouding along foot hills; fog + cold waves after passage
- **Trough in Westerlies:** Associated with Norwesters, severe TS/DS, heavy rains

11. Practice Q&A

Q1. The airmass which originates at sea in high latitudes is called:

(a) Polar maritime (b) Tropical continental (c) Tropical maritime

✅ **Answer: (a) Polar maritime (Pm)** — High latitudes + sea origin = Polar Maritime. Cold temperatures + high humidity (maritime source).

❌ (b) Tropical continental: low-latitude land origin → hot & dry. ❌ (c) Tropical maritime: low-latitude sea → warm & moist.

💡 Key: High latitude + sea = Pm. Low latitude + sea = Tm. Low latitude + land = Tc. High latitude + land = Pc.

Q2. The airmass which originates over equatorial region is:

(a) Warm and dry (b) Warm and Moist (c) Cold and dry

✅ **Answer: (b) Warm and Moist** — Equatorial Maritime (Em) originates over equatorial and tropical seas → high temperature + high humidity = warm and moist.

❌ (a) Warm & dry: Tropical Continental (Tc) — land origin. ❌ (c) Cold & dry: Polar Continental (Pc) — high latitude land.

💡 Equatorial region = over tropical seas = warm + moist = Em. The SW Monsoon is an Em air mass.

Q3. If the advancing cold front is colder than the cool air mass of the warm front, the advancing cold front undercuts and lifts both the warm and cool air masses of the warm front. This is:

(a) Warm Occlusion (b) Cold Occlusion (c) —

✅ **Answer: (b) Cold Occlusion** — Cold Occlusion: advancing cold air is COLDER than the cool air ahead → undercuts both warm and cool air masses → lifts them. Common in summers.

❌ (a) Warm Occlusion: advancing cold air is LESS COLD than the cold air ahead → overrides the warm front.

💡 Cold Occlusion = coldest air BEHIND front → undercuts everything. Warm Occlusion = less cold behind → rides over.

Q4. The airmass which originated over land area located in polar region is:

(a) Warm and dry (b) Warm and Moist (c) Cold and dry

✅ **Answer: (c) Cold and dry** — Polar Continental (Pc): polar/sub-polar land origin → cold + low humidity = cold and dry.

❌ (a) Warm & dry: Tropical Continental. ❌ (b) Warm & moist: Tropical Maritime or Equatorial Maritime.

💡 Pc = Polar (cold) + Continental (dry). The Tc air mass over India in winter originates from Siberian high = Pc characteristics.

Q5. If a warm airmass overtakes a cold air mass, it is called:

(a) Cold Front (b) Warm Front (c) Occluded Front

✅ **Answer: (b) Warm Front** — Warm Front: warm air overtaking cold air. The warm air glides up over the cold air (slope 1:150 to 1:180).

❌ (a) Cold Front: cold air overtaking warm air. ❌ (c) Occluded Front: cold front catches up with warm front.

💡 Simple definition: WARM air overtakes COLD air = Warm Front. COLD air overtakes WARM air = Cold Front.

Q6. At warm front:

(a) Warm air overtakes the cold air (b) Cold air undercuts the warm air

✅ **Answer: (a) Warm air overtakes the cold air** — At a warm front, warm air actively overtakes and glides up over the retreating cold air mass.

❌ (b) Cold air undercuts warm air = Cold Front definition.

💡 At warm front: warm air moves forward (overtakes). At cold front: cold air moves forward (undercuts). The

NAME tells you which air is advancing.

Q7. The conditions are always unstable at a:

(a) Cold front (b) Warm front

✅ **Answer: (a) Cold front** — Cold fronts always force rapid ascent of warm air → unstable conditions, CB development. Both Kata and Ana cold fronts produce CB clouds. Warm fronts can be Kata (stable) or Ana (unstable).

❌ (b) Warm front: Kata warm front = stable warm air sinking → stable conditions; only Ana warm front is unstable.

💡 Cold front = always CU/CB = always some instability. Warm front = may be stable (Kata) or unstable (Ana).

Q8. Sometimes line squall occurs 100-300 km ahead of a:

(a) Warm front (b) Cold front

✅ **Answer: (b) Cold front** — Kata type cold front sometimes moves very fast → causes a line squall **100–300 km** ahead of the front.

❌ (a) Warm front: no line squall; weather is more gradual and stratiform ahead of warm front.

💡 Line squall = 100–300 km ahead of Kata type Cold Front. This is a classic exam question.

Q9. Precipitation occurs over a belt of 30–50 km on both sides of front:

(a) Cold front (b) Warm front

✅ **Answer: (a) Cold front** — Cold front precipitation is intense but narrow — confined to a belt around the frontal surface (30–50 km on both sides). Ana type cold front precipitation: 100–150 km.

❌ (b) Warm front: precipitation extends over a much wider belt (hundreds of km ahead of front) — gradual and widespread.

💡 Cold front = narrow, intense precipitation. Warm front = wide, gradual, persistent precipitation.

Q10. Cold front moves at ... the speed of a warm front moves:

(a) Same (b) Double (c) Half

✅ **Answer: (b) Double** — A cold front normally moves at twice the speed of a warm front. This is why cold fronts eventually catch up with warm fronts, forming occluded fronts.

❌ (a) Same speed — they would never occlude. ❌ (c) Half — if true, cold fronts would always fall behind.

💡 Cold front = 2× speed of warm front → eventually catches up → Occlusion. Key exam fact.

Q11. Line Squalls occur ... of cold front:

(a) Ahead (b) Behind (c) At the

✅ **Answer: (a) Ahead** — Line squalls occur **100–300 km AHEAD** of the cold front (Kata type). They are generated by the advancing cold air mass pushing ahead of the frontal surface.

❌ (b) Behind: behind a cold front, skies typically clear. ❌ (c) At the front: the main precipitation zone is at the front itself.

💡 "100–300 km AHEAD of cold front = Line Squall" — memorise this distance.

Q12. Fronts are associated with: (a) Tropical cyclones (b) Monsoon depressions (c) Extra-tropical cyclones

✅ **Answer: (c) Extra-tropical cyclones** — Fronts form between air masses of different temperature and humidity, which is the situation in extra-tropical (mid-latitude) cyclones. Tropical cyclones and monsoon depressions have no fronts.

❌ (a) and (b) are non-frontal systems with a uniform warm, moist air mass.

💡 Tropical = no fronts. Mid-latitude lows = fronts.

Q13. CB, Roll-type clouds, SC, AC with embedded CB are associated with:

(a) Cold Front (b) Warm front

✅ **Answer: (a) Cold Front** — Cold fronts produce CU, CB clouds. Roll clouds occur behind the Gust Front (associated with the cold front). Embedded CB in Ac are associated with Ana type fronts.

❌ (b) Warm front: primarily Ci, Cs, As, Ns, St — stratiform clouds. Embedded CB only in Ana warm front.

💡 "CB = Cold Front." The strongest convection always at cold fronts.

Q14. The surface of discontinuity between air at Polar Ely and the temperate Wly is called:

(a) Equatorial Front (b) Tropopause (c) Polar Time

✅ **Answer: (c) Polar Front** — The Polar Front is the transition zone (surface of discontinuity) between polar easterlies and mid-latitude westerlies. Located around latitude 60°; not continuous; active in segments.

❌ (a) Equatorial Front: ITCZ between Trade Winds — not between polar easterlies and westerlies. ❌ (b) Tropopause: horizontal boundary between troposphere and stratosphere.

💡 Polar Easterlies vs Mid-Latitude Westerlies = Polar Front (~60°N/S).

Q15. The air mass which originates from sea area located in lower lat is:

(a) Warm and Dry (b) Warm and Moist (c) Cold and Moist

✅ **Answer: (b) Warm and Moist** — An air mass that originates over the sea in low latitudes is maritime tropical: warm from the low latitude and moist from the sea.

❌ (a) Warm and Dry is a continental tropical air mass. (c) Cold and Moist is a polar maritime air mass.

💡 Maritime = moist. Tropical = warm.

Q16. WDs approach India as:

(a) Cols (b) Occluded Fronts (c) Highs

✅ **Answer: (b) Occluded Fronts** — Western Disturbances are of frontal origin but when they reach India they are already in the occluded stage (due to the long travel distance).

❌ (a) Cols: saddle-shaped pressure patterns between highs and lows. ❌ (c) Highs: WDs are lows/depressions, not highs.

💡 WDs = extra-tropical cyclone family = arrive India as OCCLUDED fronts. Key DGCA exam point.

Q17. Maximum WDs occur in:

(a) Summers (b) Post Monsoon (c) Winters

✅ **Answer: (c) Winters** — Western Disturbances are a winter feature. They arrive at 5–7 a month in winter and are almost absent in the monsoon months.

❌ (a) Summer and (b) post-monsoon: far fewer WDs than in winter.

💡 WD = winter (December–February).

Q18. Ahead of a warm front the surface wind:

(a) Backs & weakens (b) Veers & strengthens (c) Backs & strengthens

✅ **Answer: (c) Backs & strengthens** — Ahead of a warm front (in the Northern Hemisphere), the surface wind backs (shifts anticlockwise) and strengthens as the front approaches and pressure falls.

❌ (a) Backs & weakens: not correct — wind strengthens. ❌ (b) Veers & strengthens: veering (clockwise) occurs after warm front passage.

💡 Ahead of warm front = wind BACKS. After warm front = wind VEERS. (NH). Strengthening as pressure falls

ahead of the front.

Q19. On approach of a Warm Front temperature:

(a) Fall (b) Rise (c) Remain same

✅ **Answer: (c) Remain same** — Ahead of the warm front, temperature gradually changes little; the dramatic temperature rise occurs AFTER the warm front passes (warm air replaces cold air).

❌ (a) Fall: temperatures don't fall as warm air approaches. ❌ (b) Rise: the significant temperature rise is after the warm front passage.

💡 Ahead of warm front: temperature remains roughly same (or rises slowly). After passage: temperature rises noticeably, dew point rises, humidity increases.

Q20. Ci, CS, AS, ST in sequence are associated with the front:

(a) Warm (b) Cold (c) Occluded

✅ **Answer: (a) Warm** — The sequence Ci, Cs, As, Ns, St is the classic approach of a warm front: the cloud thickens and lowers steadily as the front nears.

❌ (b) A cold front gives Cu and Cb with no gradual build-up. (c) An occlusion combines both.

💡 Warm front: Ci → Cs → As → Ns → St, getting lower.

Q21. During the passage of a Cold Front winds:

(a) Suddenly become squally (b) Back and weaken (c) Veer and are of moderate strength

✅ **Answer: (a) Suddenly become squally** — At cold front passage, the wind suddenly becomes squally (squall = sudden violent wind from the cold downdraught spreading outward). This is the Gust Front / First Gust effect.

❌ (b) Back and weaken: wind behaviour ahead of warm front. ❌ (c) Veer moderate: after warm front passage.

💡 Cold front passage = sudden squally winds + pressure rise + temperature drop + wind veer (NH).

Q22. Visibility is poor in a Warm Front:

(a) Ahead (b) Ahead & During (c) After & During

✅ Answer: (b) Ahead & During — Visibility is poor ahead of a warm front, in the drizzle, low stratus and frontal fog, and it stays poor while the front passes. It improves in the warm sector behind.

❌ (a) Ahead alone leaves out the passage itself. (c) After passage visibility improves.

💡 Warm front: poor visibility ahead and during.

Q23. Fog occurs in Cold Front:

(a) Ahead (b) During (c) After

✅ Answer: (c) After — Fog is expected after the passage of a cold front, when the cold air behind it is moist and the skies clear and winds ease.

❌ (a) Ahead of the cold front the warm sector is windy and cloudy. (b) During the passage the rain and showers are heavy.

💡 Cold front: weather during, fog possible after.

Q24. WD is a front:

(a) Cold (b) Warm (c) Occluded

✅ Answer: (c) Occluded — When WDs reach India, they are in the occluded stage. They originate as frontal systems (warm/cold fronts) but by the time they reach India, the cold front has caught up with the warm front.

❌ (a)(b) — WDs have passed the warm/cold front stage by the time they reach India.

💡 WD → India = Occluded Front. This appears in DGCA papers frequently.

Q25. FZRA and FZFG occur of a warm front:

(a) Ahead (b) During (c) After

✅ **Answer: (a) Ahead** — FZRA (Freezing Rain) and FZFG (Freezing Fog) occur ahead of a warm front. Warm rain falls through a sub-zero cold air mass ahead of the approaching warm front → freezes on contact = freezing rain. Freezing fog also forms in the cold air ahead of the front.

❌ (b)(c) — After warm front passage, temperatures rise above freezing in many cases.

💡 FZRA = warm rain falling through cold air = AHEAD of warm front. Major icing hazard for aircraft in descent.

Q26. Precipitation ceases after the passage of a front:

(a) Cold (b) Warm (c) Occluded

✅ **Answer: (b) Warm** — After a warm front passes, the rain and drizzle stop and the sky clears. After a cold front showers can continue behind the front from the cumulus and cumulonimbus.

❌ (a) Cold: showers may continue behind the cold front. (c) Occluded: bad weather can persist.

💡 Warm front: rain stops after passage. Cold front: showers may linger.

Q27. During the approach of a Cold Front wind:

(a) Backs (b) Veers (c) Does not change

✅ **Answer: (a) Backs** — Ahead of an approaching cold front in the Northern Hemisphere, the surface wind backs (shifts anticlockwise). After cold front passage, the wind veers (shifts clockwise).

❌ (b) Veers: after cold front passage. ❌ (c) Does not change: wind always changes at frontal passage.

💡 In NH: Ahead of cold/warm front → BACKS. After passage → VEERS. This holds for both fronts.

Q28. A WD with two or more closed isobars, at 2 hPa interval, is termed as:

(a) Troughs in Westerlies (b) Western Depression (c) Western Cyclone

✓ **Answer: (b) Western Depression** — When the low has two or more closed isobars at **2 hPa** interval, it is termed a **Western Depression**.

✗ (a) Troughs in Westerlies: troughs above 500 hPa level without closed isobars. ✗ (c) Western Cyclone: not a standard classification used in the text.

💡 Two closed isobars at 2 hPa = Western Depression. Just a trough = Trough in Westerlies. Key DGCA distinction.

Q29. A WD originate over:

(a) Baluchistan (b) Caspian sea (c) Mediterranean, Caspian and Black Seas

✓ **Answer: (c) Mediterranean, Caspian and Black Seas** — WDs originate over the Mediterranean Sea, Caspian Sea, and Black Sea; they move eastwards across north India.

✗ (a) Baluchistan: not a source — WDs pass over this region. ✗ (b) Caspian sea only: incomplete; all three seas are source regions.

💡 WD origin: Mediterranean + Caspian + Black Sea. Three seas = three sources.

Q30. Induced lows develop to the ... of a WD:

(a) N (b) S (c) NE

✓ **Answer: (b) S (South)** — Under the influence of a WD, a low sometimes develops to the SOUTH of the system (induced low), and a cyclonic circulation sometimes develops to the south (induced cyclonic circulation).

✗ (a) North: the WD itself is north of induced systems. ✗ (c) NE: not the stated direction.

💡 WD is in N India → Induced Low forms to the SOUTH. This can affect central/peninsular India with rain even when the WD is far to the north.

12. Master Reference Tables

All Numerical Values — Chapter 14

Parameter	Value
Air mass types	6 (A, Pc, Pm, Tc, Tm, Em)
SW Monsoon air mass	Em (Equatorial Maritime)
Most common winter air mass over India	Tc (Tropical Continental) from Siberian High
Em prevails south of	25°N during monsoon
Cold front average slope	1:50
Kata Cold Front slope	1:120
Kata Cold Front speed	About 20 kt
Ana Cold Front slope	1:50
Ana Cold Front speed	Exceeds 30 kt
Ana Cold Front precipitation width	100–150 km
Line squall distance ahead of cold front	100–300 km
Warm Front slope	1:150 to 1:180
Warm Front speed	About 10–15 kt
Cold front speed relative to warm front	Twice (2×) the speed of warm front
Kata warm front: Ci,Cs spotted at	1000 km ahead of front
Kata warm front: NS,AS at	400–500 km from front
Polar Front latitude	Around 60°N/S
WD: two closed isobars at	2 hPa interval = Western Depression
WD move north of	20°N

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WD troughs above	500 hPa = Troughs in Westerlies
WD frequency in winters	5–7 per month
WD frequency in monsoon	NIL
WD reappear from	October onwards
WD rate of movement	About 250–300 km per day
WD primary area affected (~50% cases)	J&K, HP, Punjab, Haryana, Uttarakhand, Sikkim, Bhutan, Arunachal

Mnemonics

- **Air mass memory:** "A Pc Pm Tc Tm Em" = Arctic, Polar Continental, Polar Maritime, Tropical Continental, Tropical Maritime, Equatorial Maritime
- **Continental = Dry; Maritime = Moist; Polar = Cold; Tropical = Warm**
- **SW Monsoon = Em** (Equatorial Maritime = hot + very humid)
- **India winter = Tc** (Siberian High → cold dry → poor visibility)
- **Cold front = steeper (1:50); Warm front = shallower (1:150–180)**
- **Cold front = TWICE speed of warm front → Occlusion**
- **Kata = Katabatic (sinking warm air) = stratiform; Ana = Anabatic (rising warm air) = convective/CB**
- **Warm front clouds (1000→0 km): "Ci Cs As Ns St FOG"**
- **Cold Occlusion = Coldest air behind = Undercuts; Summers**
- **WD: "Med-Cas-Black = Origin; 5-7/month winter; NIL monsoon; Oct reappear; 250-300 km/day"**
- **WD → India = Occluded Front**
- **Line squall = 100–300 km AHEAD of cold front**
- **FZRA = AHEAD of warm front** (rain falls through sub-zero cold air)