Heating Ventilation Air Conditioning (315373)

Model Question Paper — Set A · Model Answers

Q.1

a) Dew point temperature and dew point depression. 2 M

Dew point temperature (DPT): The temperature to which moist air must be cooled at constant pressure (constant ω) so that water vapour in it just starts condensing. It is the saturation temperature corresponding to the partial pressure of vapour p_v.

Dew point depression (DPD): The difference between dry bulb temperature and dew point temperature, DPD = DBT − DPT. For saturated air DPD = 0.

(Each definition 1 M)

b) Dalton's law of partial pressures. 2 M

Dalton's law of partial pressures: The total pressure exerted by a mixture of ideal gases (which do not react chemically) is equal to the sum of the partial pressures that each gas would exert if it alone occupied the whole volume at the same temperature.

For atmospheric (moist) air: $p_b = p_a + p_v$, where p_b = barometric pressure, p_a = partial pressure of dry air, p_v = partial pressure of water vapour.

(Statement 1 M, equation for moist air 1 M)

c) Classification of compressors. 2 M

- **According to principle:** (i) Positive displacement — reciprocating, rotary (rolling piston / rotary vane), screw, scroll; (ii) Roto-dynamic — centrifugal.
- **According to arrangement of motor:** open type, semi-hermetic (accessible hermetic), hermetically sealed.
- **According to number of stages:** single stage, multi-stage.
- Also by number of cylinders (single/multi) and by action (single acting / double acting).

(Any two bases with types, 1 M each)

d) Necessity of air conditioning. 2 M

- **Human comfort:** maintains comfortable temperature, humidity, air motion and clean air in homes, offices, theatres, hospitals.
- **Industrial processes:** textile, printing, pharmaceuticals, electronics and precision manufacturing need controlled temperature and humidity.
- **Health:** operation theatres and ICUs need dust/bacteria-free conditioned air.
- **Preservation:** computer/server rooms, museums, food storage — to protect equipment and materials.
- Improves work efficiency and productivity of people.

(Any four, ½ M each)

e) Requirements for installation of HVAC system. 2 M

- Proper location: strong support/foundation, enough clearance for air flow and service; outdoor unit away from direct sun, shaded and ventilated.
- Correct size (capacity) of equipment selected as per cooling load calculation.
- Electrical supply of correct voltage with proper earthing, MCB and stabiliser.
- Leak-proof refrigerant piping of correct size with proper insulation; evacuation and charging done correctly.
- Proper condensate drain with slope; levelling of unit; vibration isolation pads.
- Testing after installation — leak test, pressure test, running current and air delivery checked.

(Any four, ½ M each)

f) Necessity of cooling load calculation. 2 M

- To select the correct **capacity (TR) of plant** — undersized plant cannot maintain conditions, oversized plant wastes money and controls humidity poorly.
- **Energy efficiency:** correct size gives lower running cost.
- To decide **air quantity**, supply temperature (from SHF) and to size ducts, coils, fans and pipes.
- To ensure **occupant comfort** — correct temperature and humidity under peak load.

(Any four, ½ M each)

g) Air Handling Unit (AHU). 2 M

Air handling unit (AHU): An AHU is a large metal box (equipment) that conditions and circulates air in a central AC system. It takes return air and fresh air, mixes, filters, cools/heats, humidifies/dehumidifies it and supplies it through ducts to the conditioned space by its fan.

Main parts: mixing box with dampers, filters, cooling coil with drain pan, heating coil, humidifier, supply fan (blower) and sound attenuator.

(Definition 1 M, parts 1 M)

Q.2

a) Hermetic vs open type reciprocating compressor. 4 M

Basis	Hermetically sealed compressor	Open type reciprocating compressor
Construction	Motor and compressor are mounted on a common shaft and sealed inside a welded steel shell; no shaft seal.	Compressor is driven by a separate motor through belt or coupling; crankshaft comes out through a shaft seal.
Capacity	Small capacities — fractional kW up to about 10–15 TR (domestic & room units).	Medium and large capacities (up to several hundred TR).
Application	Domestic refrigerators, water coolers, window/split AC, small packaged units.	Cold storages, ice plants, ammonia plants, industrial and large AC plants.
Lubrication & maintenance	Splash/forced lubrication inside shell; oil sealed for life. Cannot be repaired on site	Separate lubrication arrangement; needs regular maintenance of belt,

	— whole unit replaced; practically maintenance free.	seal, oil. Easily dismantled and repaired at site.

(Each basis 1 M)

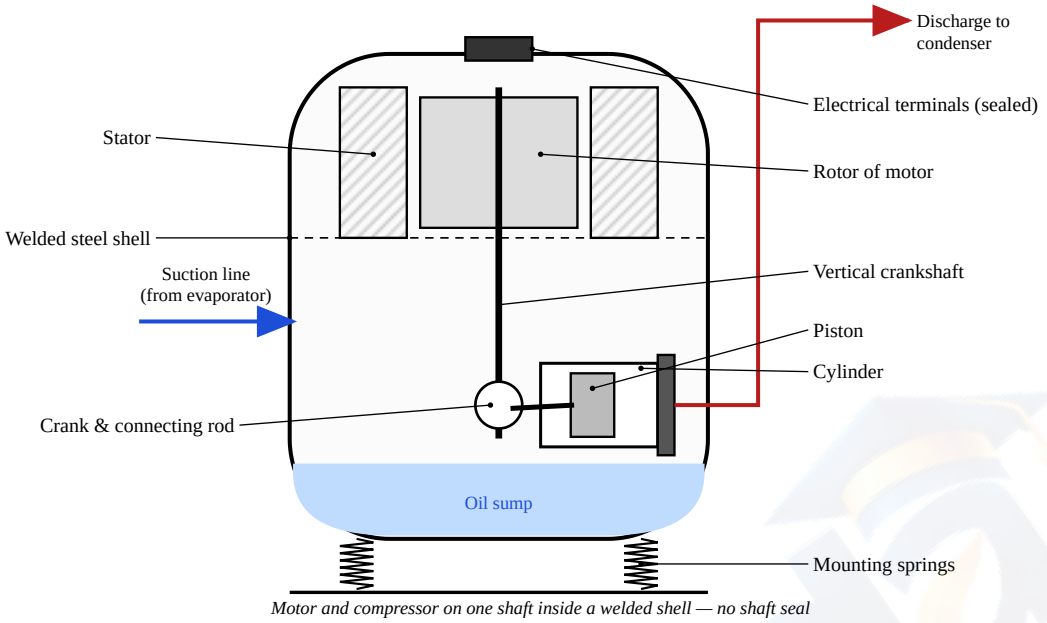
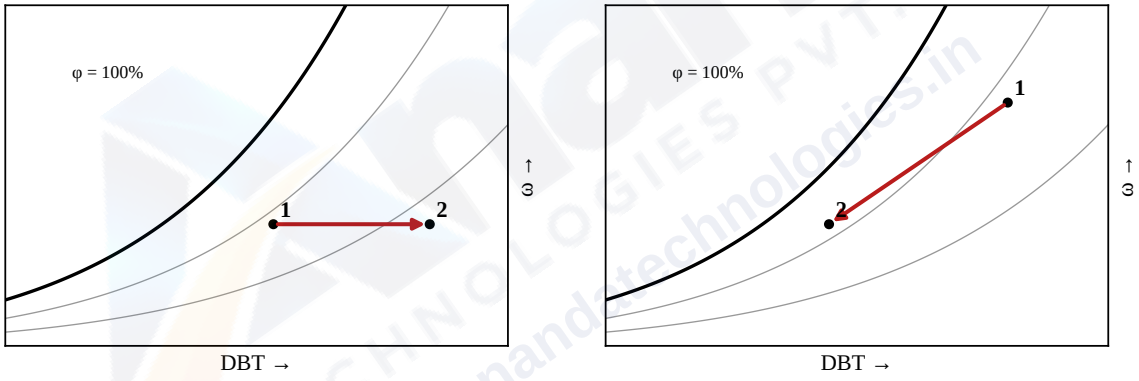


Fig.: Hermetically sealed reciprocating compressor (schematic section)

b) Sensible heating and cooling & dehumidification on psychrometric chart. 4 M



(i) Sensible heating *(ii) Cooling & dehumidification*

Sensible heating (1–2): Air is heated without adding or removing moisture (e.g. over a steam/electric heating coil). DBT increases, ω and DPT remain constant, RH decreases, enthalpy increases. It is a horizontal line towards the right on the chart. Heat added = $m(h_2 - h_1) = m\ c_{pa}(t_2 - t_1)$, $c_{pa} \approx 1.022$ kJ/kg K for humid air.

Cooling and dehumidification (1–2): Air is passed over a cooling coil whose surface temperature (ADP) is below the dew point of air. Both DBT and ω fall; moisture condenses and is drained. The process line goes downwards and to the left. Used in all summer air-conditioning. Heat removed = $m(h_1 - h_2)$, moisture removed = $m(\omega_1 - \omega_2)$.

(Each process: sketch 1 M + explanation 1 M)

c) Flooded type evaporator. 4 M

In a **flooded evaporator** the evaporator shell/coil is always kept full of liquid refrigerant; only vapour formed is drawn by the compressor. The liquid level is kept constant by a **float valve**.

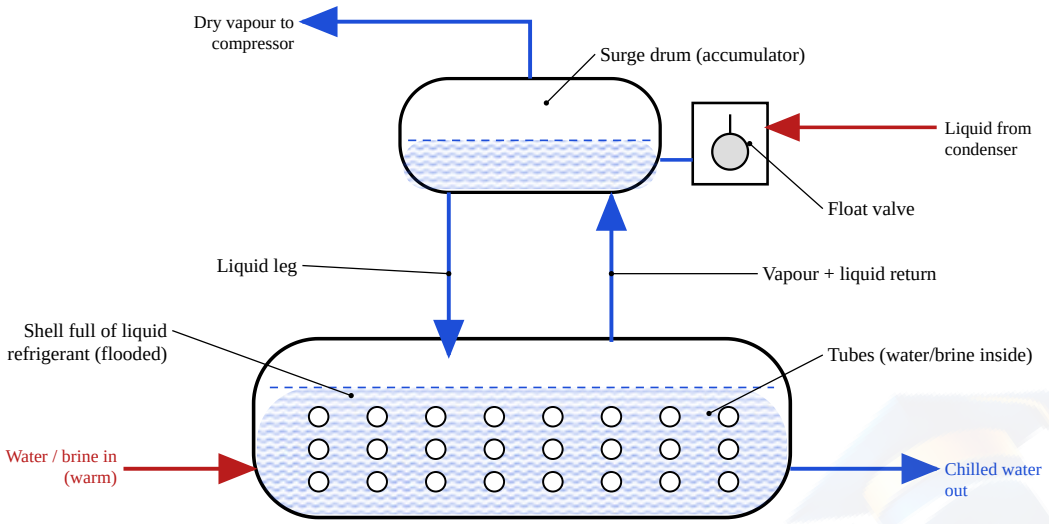


Fig.: Flooded type (shell and tube) evaporator with surge drum and float valve

Working:

1. High pressure liquid from the condenser enters the surge drum (accumulator) through the float valve, which maintains a constant liquid level.
2. Liquid flows by gravity through the liquid leg to the bottom of the evaporator shell, so the tubes are fully submerged in liquid refrigerant.
3. Water/brine flowing inside the tubes gives heat to the refrigerant, which boils; the mixture of vapour and liquid rises back to the surge drum.
4. In the drum, liquid separates and recirculates; only dry saturated vapour goes from the top of the drum to the compressor suction — so no liquid enters the compressor.

Features: whole surface wetted → high heat transfer coefficient; needs a large refrigerant charge.
Applications: large water/brine chillers, ammonia plants, ice plants.

(Sketch 2 M, working 2 M)

d) Properties of insulating material. 4 M

- Low thermal conductivity (k ≈ 0.02–0.05 W/m K).
- Low density (light weight) and low specific heat.
- Low water-vapour absorption / should be non-hygroscopic (moisture reduces insulating value).
- Fire resistant / non-inflammable and odourless.
- Should not be attacked by vermin, fungus; chemically stable and durable.
- Easy to apply/fix, available in convenient forms, low cost.
- Should have sufficient mechanical strength and should not settle or shrink.

Common materials: expanded polystyrene (thermocole), polyurethane foam (PUF), glass wool, mineral (rock) wool, nitrile rubber (closed-cell elastomeric) foam, cork, XLPE foam.

(Any four properties, 1 M each)

Q.3

a) Concept of heat pump with p–h diagram. 4 M

Heat pump: A heat pump is a machine working on the reversed Carnot / vapour compression cycle which extracts heat Q_2 from a low-temperature source (outside atmosphere) and delivers a larger quantity of heat $Q_1 = Q_2 + W$ to the space to be heated, using work input W. The same system used for cooling the space is called a refrigerator/air conditioner — only the useful effect is different.

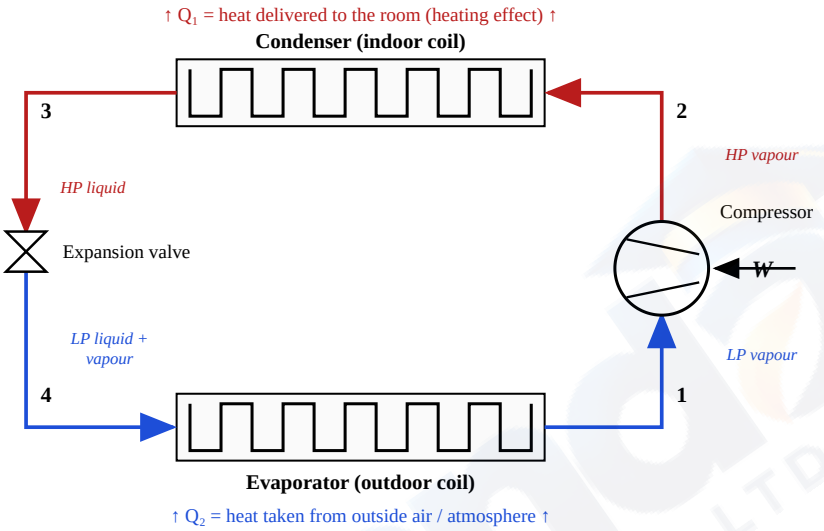


Fig.: Heat pump (vapour compression system used for heating)

- **Evaporator (outdoor coil):** low pressure liquid evaporates by absorbing heat Q_2 from outside air.
- **Compressor:** raises pressure and temperature of vapour (work W).
- **Condenser (indoor coil):** hot vapour condenses and gives heat Q_1 to the room — this is the useful heating.
- **Expansion valve:** throttles the liquid back to evaporator pressure.
- $COP_{HP} = Q_1/W = (Q_2 + W)/W = COP_R + 1$. A reversing (4-way) valve lets the same unit cool in summer and heat in winter.

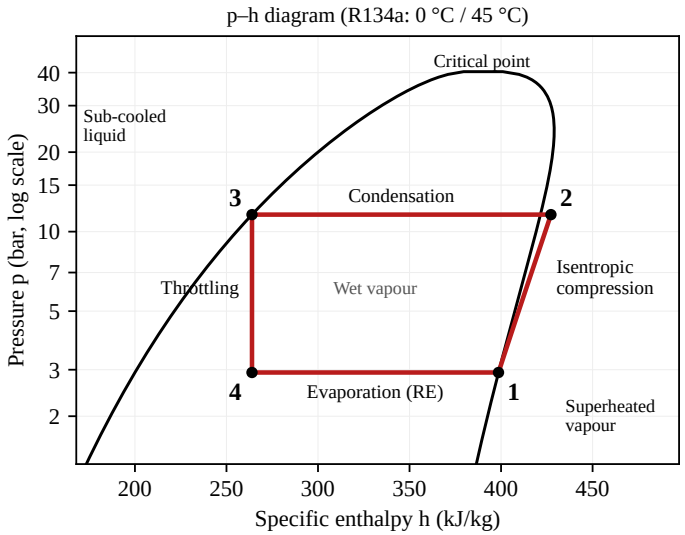


Fig.: Heat pump cycle on p–h diagram (computed for R-134a, evaporator 0 °C, condenser 45 °C): h_1 = 398.6, h_2 = 427.2, $h_3 = h_4$ = 263.9 kJ/kg → $COP_{HP} = (h_2 - h_3)/(h_2 - h_1)$ = 5.70

(Concept 1 M, sketch 2 M, p–h diagram 1 M)

b) Layout of automobile air conditioning system.

4 M

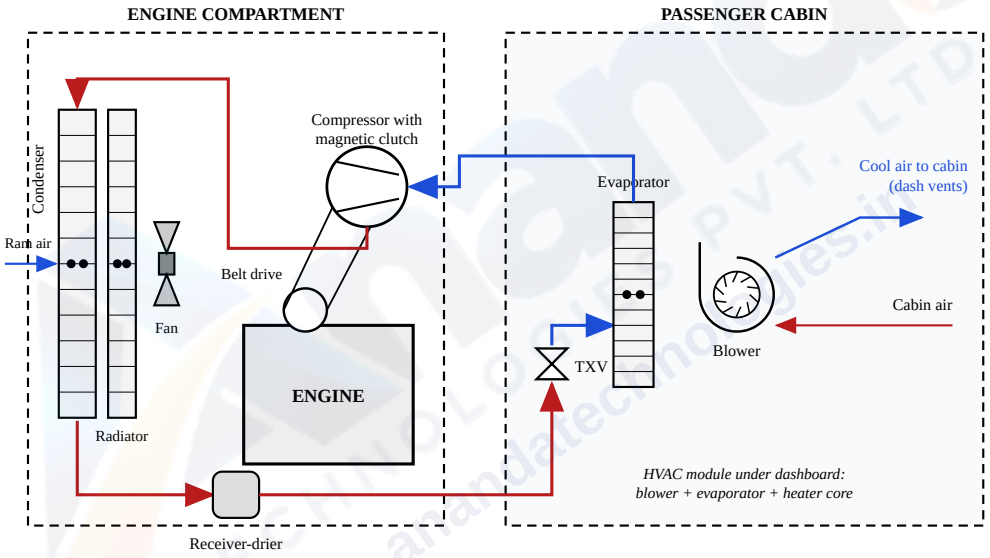


Fig.: Layout of automobile (car) air conditioning system

Components and working:

- **Compressor** (swash-plate/scroll) driven by the engine through a belt and **electromagnetic clutch**; clutch engages when AC is switched on.
- **Condenser** in front of the radiator — cooled by ram air and the radiator fan; vapour condenses to liquid.
- **Receiver-drier** stores liquid and removes moisture and dirt (desiccant + filter).
- **Expansion valve (TXV)** or orifice tube reduces pressure and meters refrigerant to the evaporator.
- **Evaporator** in the HVAC module under the dashboard; the **blower** passes cabin/fresh air over it and cool, dry air enters the cabin through dash vents.

- Refrigerant R-134a / R-1234yf; thermostat/pressure switches cycle the clutch.

(Layout 2 M, explanation 2 M)

c) Central vs unitary air conditioning system. 4 M

Central air conditioning system	Unitary air conditioning system
All equipment (compressor, condenser, chiller, AHU) is at one central plant; conditioned air/chilled water is distributed by ducts/pipes to all rooms.	Factory-assembled self-contained unit (window, split, packaged) placed in or near the room to be conditioned.
Used for large capacity — above about 25 TR (malls, hotels, hospitals, theatres).	Used for small capacity — 0.75 to 25 TR (rooms, small offices, shops).
High initial cost, but lower running cost per TR; long life.	Low initial cost, easy to install; higher running cost per TR.
Needs separate plant room, ducts, skilled operators.	No plant room; ductless or short ducts; simple operation.
Better control of humidity, filtration and fresh air for the whole building.	Control only for the individual room; fresh-air and humidity control limited.
Breakdown affects the whole building.	Breakdown affects only one room.

(Any four points, 1 M each)

d) Calculation of occupant load. 4 M

Heat released by a person depends on activity level and room temperature. It has a **sensible** part (convection + radiation from body) and a **latent** part (moisture from breathing and sweat).

Occupant load: Q_s = N × SHG per person; Q_L = N × LHG per person; where N = number of occupants (from seating capacity or floor area ÷ area per person), SHG/LHG from tables (ASHRAE/Carrier) for the activity at room temperature. A diversity factor is used when all occupants are not present at the same time.

Activity (room at 25–26 °C)	Sensible heat (W/person)	Latent heat (W/person)
Seated at rest (theatre)	65	30
Seated, light work (office, classroom)	70–75	45–55
Moderately active (laboratory)	75	75
Light bench work / walking	80–90	140
Heavy work (gym)	170	255

Example: classroom of 60 students (light work): Q_s = 60 × 75 = 4500 W; Q_L = 60 × 55 = 3300 W; total occupant load = 7.8 kW.

(Explanation 2 M, formula/table 1 M, example 1 M)

Q.4

a) Sensible and latent heat gain; sources of sensible heat gain. 4 M

Sensible heat gain: heat that enters or is generated in the conditioned space and raises the **dry bulb temperature** of room air, without changing its moisture content.

Latent heat gain: heat gained due to addition of **moisture** (water vapour) to the room air — it raises specific humidity, not DBT (e.g. from people's breathing and sweat).

Sources of sensible heat gain:

- Conduction through walls, roof, floor and partitions ($Q = U\,A\,\Delta T$).
- Solar radiation through glass (windows) and heat through glass by conduction.
- Occupants (sensible part of body heat).
- Electric lights (× 1.25 for fluorescent ballast), motors, computers, projectors and other appliances.
- Infiltration and ventilation (fresh) air — sensible part.
- Duct heat gain, fan work (supply air fan) and products / equipment.

(Definitions 2 M, sources 2 M)

b) Extended plenum duct system. 4 M

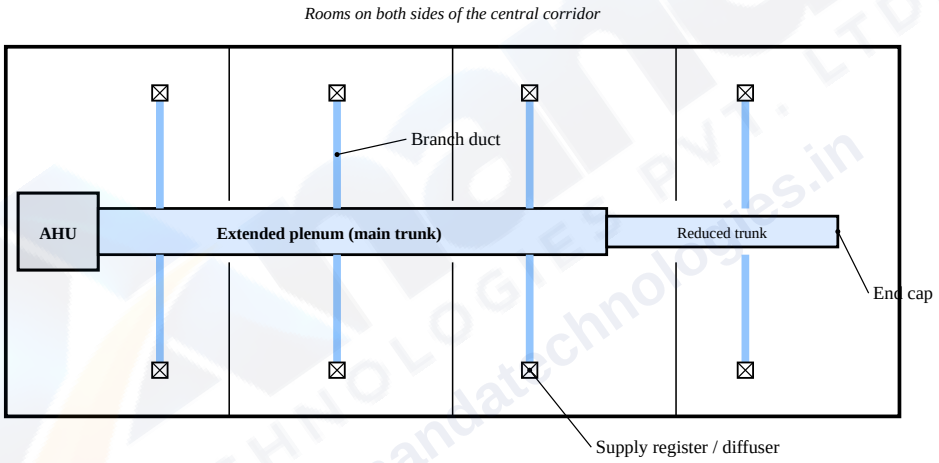


Fig.: Extended plenum duct system (plan view)

Explanation:

- A large rectangular **main trunk (plenum)** is taken from the AHU/furnace and **extended in a straight line** along the centre of the building (usually over the corridor).
- Its size is kept **constant** for a certain length (extended plenum) and then reduced, unlike a reducing-trunk system where it is reduced after each branch.
- Short **branch ducts** are taken from both sides of the plenum to supply registers/diffusers in each room.
- Constant size keeps nearly equal static pressure at all take-offs, so air distribution is uniform and balancing is easy.
- Simple, economical (less fittings), easy to install; used in residences, offices and single-storey buildings with a central corridor. Not suitable for very long runs (> 15–18 m) without reduction.

(Sketch 2 M, explanation 2 M)

c) Air-cooled condenser. 4 M

In an **air-cooled condenser** heat from the hot refrigerant vapour is rejected to atmospheric air flowing over finned tubes.

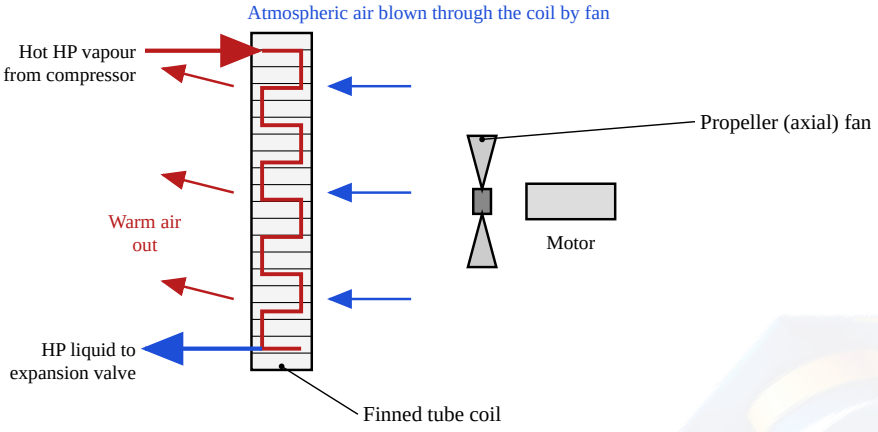


Fig.: Air cooled condenser (forced convection)

- Hot, high pressure vapour from the compressor enters the top header of the finned copper/aluminium tube coil.
- A propeller (axial) fan driven by a motor forces atmospheric air across the fins (forced convection; small refrigerators use natural convection).
- Vapour gives up superheat and latent heat to air, condenses, and leaves as high pressure liquid at the bottom to the expansion device.
- Fins increase the heat transfer area on the air side.

Applications: domestic refrigerators, water coolers, window/split AC, packaged units and small plants (generally up to about 20 TR) where water is scarce.

(Sketch 2 M, working 1 M, applications 1 M)

d) Grilles, registers and diffusers. 4 M

Supply air outlets are the terminal devices that deliver conditioned air into the room and distribute it without draught or noise:

- **Grilles:** rectangular outlets with fixed or adjustable vanes (bars); used for supply and return; no volume control.
- **Registers:** grille combined with a volume control damper behind it — controls both direction and quantity of air.
- **Diffusers:** ceiling outlets (square, round, linear slot) with concentric cones/louvres; spread air in many directions and mix it rapidly with room air.
- Other outlets: slot (linear) diffusers, perforated ceiling panels, nozzles / jet diffusers (auditoriums, halls), floor (swirl) diffusers.

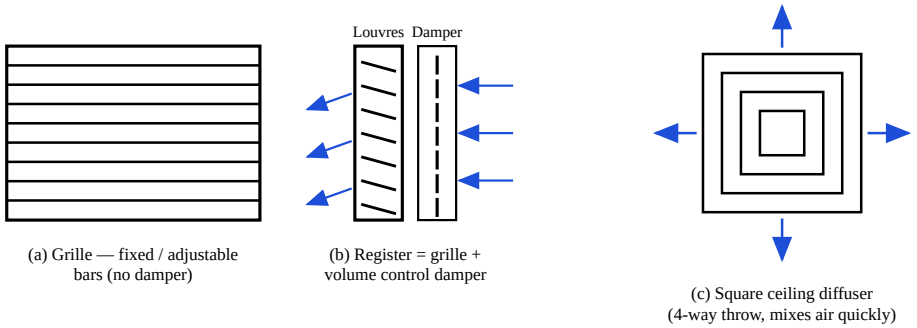


Fig.: Supply air outlets — (a) grille (b) register (c) ceiling diffuser

Functions: (1) deliver and spread supply air uniformly in the occupied zone; (2) control direction (throw) and quantity of air; (3) mix supply air with room air to avoid cold draught; (4) give a neat appearance and keep noise low.

(Description 2 M, sketch 1 M, functions 1 M)

e) Duct materials and their properties. 4 M

Duct materials:

- Galvanised iron (GI) sheet — most common
- Aluminium sheet
- Stainless steel (kitchen exhaust, clean rooms)
- Pre-insulated phenolic / PIR panel ducts
- Fibre-glass board and flexible ducts
- PVC / FRP (corrosive fumes), copper, black steel (high temperature)

Desirable properties:

- Low cost and easily available.
- Smooth inner surface — low friction loss.
- Light weight, easy to fabricate, join and support.
- Corrosion resistant and durable; fire resistant.
- Airtight joints, low noise transmission, low heat gain (or easy to insulate).

(Four materials 2 M, four properties 2 M)

Q.5

a) Properties of air at 32 °C DBT, 55 % RH. 6 M

Given: DBT = 32 °C, RH = 55 %, standard atmospheric pressure p = 101.325 kPa.

> **Formulas used** (p = 101.325 kPa; saturation pressures from steam tables):
> $p_v = \varphi \cdot p_{vs}$ · $\omega = 0.622\ p_v/(p - p_v)$ · $h = 1.005\ t + \omega(2500 + 1.88\ t)$ kJ/kg d.a.
> Carrier's equation: $p_v = p_{vw} - (p - p_{vw})(t_d - t_w)/(1544 - 1.44\ t_w)$ · DPT = saturation temperature corresponding to p_v

Step 1 – Vapour pressure: From steam tables, p_{vs} at 32 °C = 4.7596 kPa.

$p_v = \varphi \times p_{vs} = 0.55 \times 4.7596 =$ **2.6178 kPa**

Step 2 – Dew point temperature: DPT = saturation temperature at p_v = 2.6178 kPa → **DPT = 21.8 °C**

Step 3 – Specific humidity: $\omega = 0.622 \times 2.6178 / (101.325 - 2.6178) =$ **0.0165 kg/kg d.a.**

Step 4 – Enthalpy: $h = 1.005 \times 32 + 0.0165 \times (2500 + 1.88 \times 32) =$ **74.39 kJ/kg d.a.**

Step 5 – Wet bulb temperature: found by trial from Carrier's equation such that p_v = 2.6178 kPa: at t_w = 24.6 °C, p_{vw} = 3.0984 kPa and $3.0984 - (101.325 - 3.0984)(32 - 24.6)/(1544 - 1.44 \times 24.6) \approx 2.618$ kPa ✓ → **WBT ≈ 24.6 °C**

Step 6 – Specific volume: $v = 0.287\ (T)/(p - p_v) = 0.287 \times 305.15/(101.325 - 2.618) =$ **0.887 m³/kg d.a.**

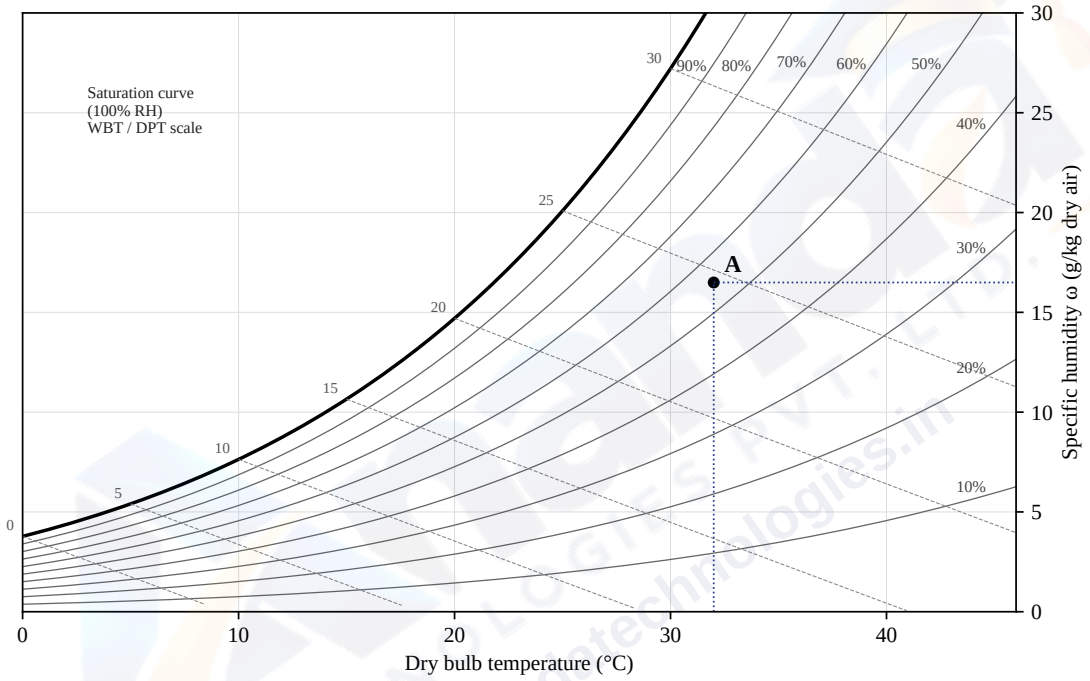


Fig.: State point A on psychrometric chart (DBT 32 °C, φ 55 %) — chart computed from the same formulas

Answer:

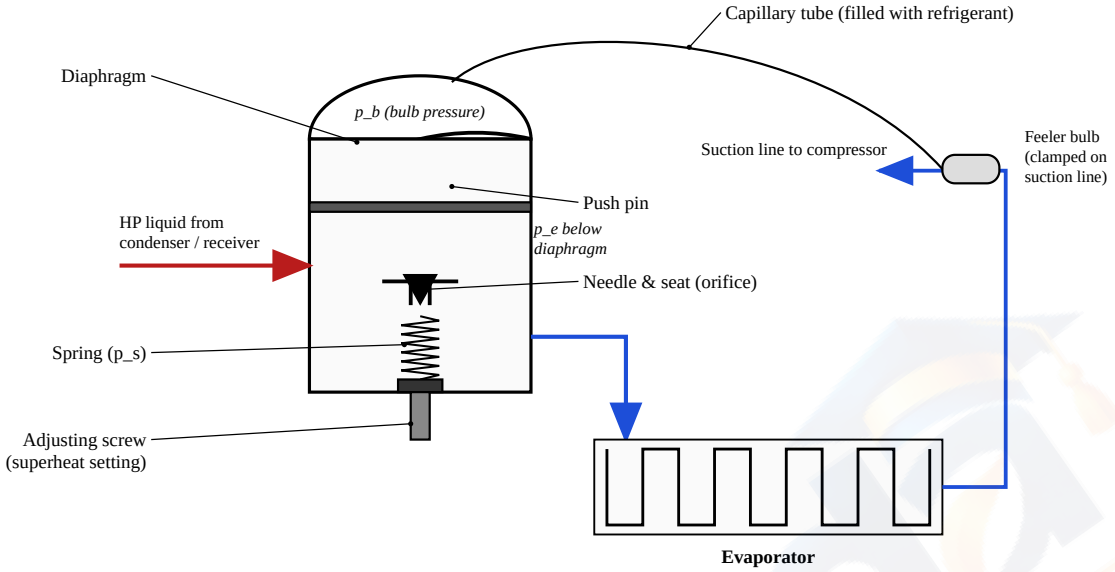
Property	Value
Dry bulb temperature (DBT)	32.0 °C
Wet bulb temperature (WBT)	24.6 °C
Dew point temperature (DPT)	21.8 °C
Relative humidity φ	55.0 %
Specific humidity ω	0.0165 kg/kg d.a. = 16.50 g/kg d.a.
Enthalpy h	74.39 kJ/kg d.a.
Specific volume v	0.887 m³/kg d.a.

Values read from a printed chart will agree within reading accuracy (±0.5 °C, ±0.3 g/kg, ±1 kJ/kg).

(Each property 1 M)

b) Thermostatic expansion valve. 6 M

The **thermostatic expansion valve (TEV)** controls refrigerant flow into the evaporator so as to keep a **constant degree of superheat** (≈ 5 °C) at the evaporator outlet, whatever the load.



Balance: p_b = p_e + p_s ; more superheat → p_b rises → valve opens more

Fig.: Thermostatic expansion valve (TEV / TXV)

Construction: valve body with needle and seat; a diaphragm at the top; a feeler bulb clamped on the evaporator outlet (suction line) connected to the space above the diaphragm by a capillary tube; an adjustable spring below the needle.

Working: Three pressures act on the diaphragm — bulb pressure p_b (above, tends to open), evaporator pressure p_e and spring pressure p_s (below, tend to close). At balance $p_b = p_e + p_s$.

- When load increases, refrigerant evaporates earlier, superheat at outlet rises, bulb temperature and p_b rise → diaphragm moves down → valve opens more → more refrigerant flows.
- When load decreases, superheat falls, p_b falls → valve closes partly → less flow.
- Thus the evaporator is always fed correctly and liquid cannot flood back to the compressor.

Applications: (1) window/split/packaged and central AC plants with DX coils; (2) commercial refrigeration — cold storages, display cabinets, water coolers; (3) automobile AC.

(Sketch 2 M, working 3 M, applications 1 M)

c) Year-round air conditioning system. 6 M

A **year-round air conditioning system** maintains the desired inside condition (e.g. 24 °C, 50 % RH) in **all seasons** — it cools and dehumidifies in summer and heats and humidifies in winter, controlled automatically by thermostat and humidistat.

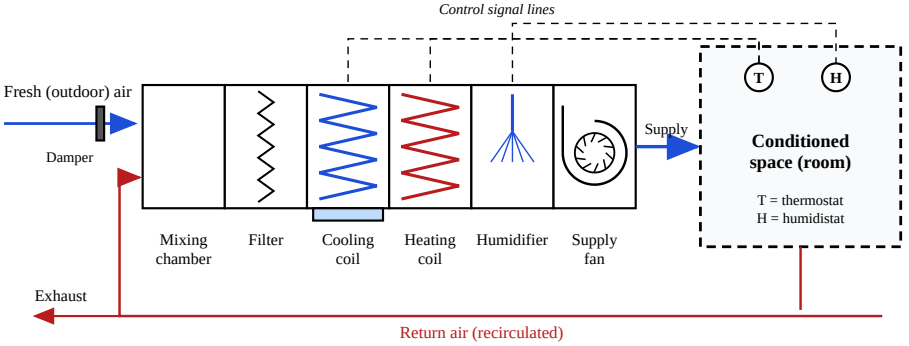


Fig.: Year-round air conditioning system

Working:

1. Return air from the room is mixed with fresh outdoor air in the mixing chamber (dampers control proportion); part of the room air is exhausted.
2. The mixture is cleaned in the **filter**.
3. **Summer:** the cooling coil (chilled water / DX) cools and dehumidifies the air; heating coil works as re-heater only if needed; humidifier is off.
4. **Winter:** the cooling coil is off; the heating coil heats the air and the humidifier (steam/water spray) adds moisture.
5. The supply fan delivers conditioned air through ducts to the room.
6. The room **thermostat** controls the cooling/heating coils and the **humidistat** controls the humidifier (and cooling coil for dehumidification).

Applications: hospitals, hotels, laboratories, computer centres, auditoriums in places with both hot and cold seasons.

(Sketch 3 M, working 3 M)

Q.6

a) Cooling load of a classroom. 6 M

Assumed data: students seated, light work — 75 W sensible + 55 W latent per person; wall and glass $\Delta T = 40 - 25 = 15$ °C; fresh air 5 L/s per person; infiltration 1 air change per hour; $\rho_{air} = 1.2$ kg/m³, $c_{p,humid} = 1.0216$ kJ/kg K, $h_{fg} \approx 2500$ kJ/kg; safety factor 10 %.

Room data (assumed): 10 m × 8 m × 3.5 m (volume 280.0 m³). Outside design: 40 °C DBT, 40 % RH ($\omega_o = 0.0187$ kg/kg); inside design: 25 °C DBT, 50 % RH ($\omega_i = 0.0099$ kg/kg) — ω from $\omega = 0.622 p_v/(p - p_v)$.

Source of heat gain	Calculation	Sensible (W)	Latent (W)
Exposed wall	$Q = U\,A\,\Delta T = 1.8 \times 30.0 \times 15$	810	—
Roof (equivalent ΔT)	$Q = U\,A\,\Delta T = 1.2 \times 80.0 \times 18$	1728	—

Glass (conduction)	$Q = U\,A\,\Delta T = 5.8 \times 6.0 \times 15$	522	—
Solar gain through glass	$A \times q_{solar} = 6.0 \times 200$ W/m²	1200	—
Occupants (60 persons)	SH = 60 × 75 W; LH = 60 × 55 W	4500	3300
Lighting (fluorescent)	640 W × 1.25 (ballast factor)	800	—
Projector	1 × 300 W	300	—
Ceiling fans (motor heat)	6 × 60 W	360	—
Infiltration (1 air change/h)	$\dot{V} = 0.0778$ m³/s, $\dot{m} = 1.2\,\dot{V} = 0.0933$ kg/s SH = $\dot{m} \times 1.0216 \times (40 - 25)$ LH = $\dot{m} \times 2500 \times (0.0187 - 0.0099)$	1430	2052
Ventilation (fresh) air 5 L/s per person	$\dot{V} = 0.3000$ m³/s, $\dot{m} = 1.2\,\dot{V} = 0.3600$ kg/s SH = $\dot{m} \times 1.0216 \times (40 - 25)$ LH = $\dot{m} \times 2500 \times (0.0187 - 0.0099)$	5517	7914
Sub-total		**17167**	**13266**
Add 10 % safety factor		**18884**	**14593**

Total cooling load = 18884 + 14593 = **33477 W = 33.48 kW**. In tonnes of refrigeration (1 TR = 3.517 kW): **9.52 TR**. Room SHF = 18884/33477 = **0.56** → select a 10.0 TR unit (next standard size).

(Listing of loads 2 M, calculations 3 M, total in TR 1 M)

b) Rectangular duct — total pressure and air power. 6 M

Given: a × b = 0.3 m × 0.2 m, L = 25 m, Q = 0.6 m³/s, f = 0.005, standard air ρ = 1.2 kg/m³.

Area A = 0.3 × 0.2 = 0.0600 m²; perimeter P = 2(0.3 + 0.2) = 1.00 m

Hydraulic mean depth m = A/P = 0.0600/1.00 = 0.06000 m (equivalent diameter $D_h = 4m = 0.2400$ m)

Velocity V = Q/A = 0.6/0.0600 = **10.00 m/s**

Friction loss (Fanning / Darcy form): $\Delta p_f = f\,L\,\rho\,V^2 / (2\,m) = 0.005 \times 25 \times 1.2 \times 10.00^2 / (2 \times 0.06000)$ = **125.0 Pa**

Velocity pressure $p_v = \rho V^2/2 = 1.2 \times 10.00^2/2$ = **60.0 Pa**

Total pressure required at inlet $p_t = \Delta p_f + p_v = 125.0 + 60.0$ = **185.0 Pa** (= 18.9 mm of water)

Air power = $Q \times p_t = 0.6 \times 185.0$ = **111.0 W**

(i) Equal velocity (same V and friction per metre): $D_e = 2ab/(a + b) = 2 \times 0.3 \times 0.2/(0.3 + 0.2)$ = **0.240 m = 240 mm**

(ii) Equal flow rate and equal friction (Huebscher): $D_e = 1.3\,(ab)^{0.625}/(a + b)^{0.25} = 1.3 \times (0.0600)^{0.625}/(0.50)^{0.25}$ = **0.266 m = 266 mm**

Answers: V = 10.0 m/s; Δp_f = 125.0 Pa; total pressure at inlet = **185.0 Pa**; air power = **111.0 W**; D_e (equal friction) = 266 mm

(Velocity & m 1 M, friction loss 2 M, total pressure 1 M, air power 1 M, D_e 1 M)

c) Types of fans; centrifugal fan. 6 M

Types of fans used in air conditioning:

- **Centrifugal fans** — forward curved, backward curved (and aerofoil), radial blades.
- **Axial fans** — propeller, tube-axial, vane-axial.
- Mixed-flow and cross-flow (tangential) fans.

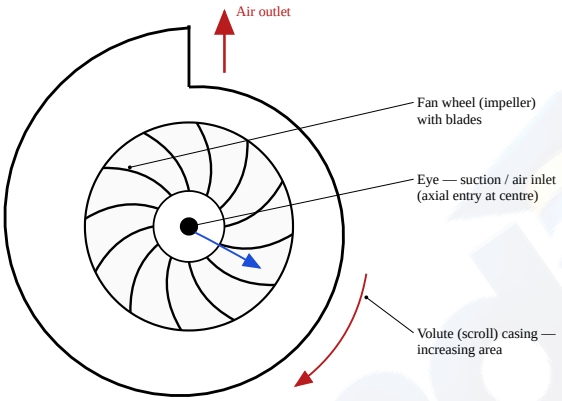


Fig.: Centrifugal fan (blower)

Centrifugal fan — working: Air enters axially through the eye of the rotating wheel, is turned 90° and thrown radially outward by the blades, gaining velocity and pressure. The scroll (volute) casing with increasing area converts part of the velocity into static pressure and delivers the air to the duct. Backward-curved blades give high efficiency and non-overloading power; forward-curved blades are compact and quiet (used in AHUs, window AC blowers).

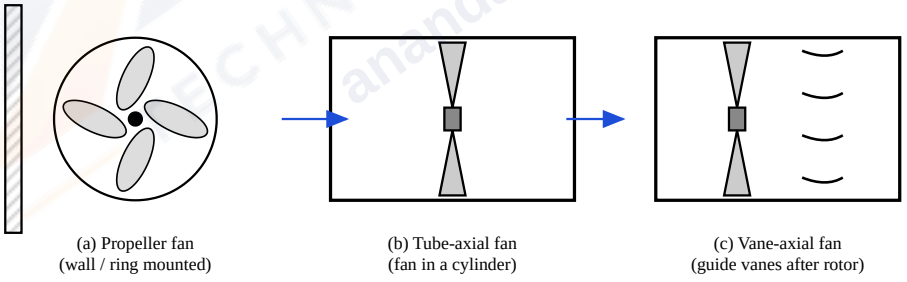


Fig.: Axial flow fans — (a) propeller (b) tube-axial (c) vane-axial

(Types 2 M, sketch 2 M, explanation 2 M)

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