

Heating Ventilation Air Conditioning (315373)

Model Question Paper — Set C · Model Answers

Q.1

a) Relative humidity and specific humidity.

2 M

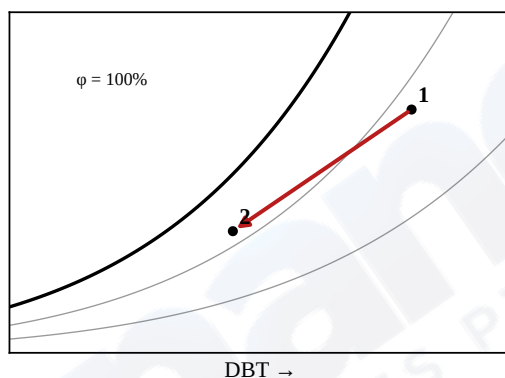
Relative humidity (ϕ): The ratio of the actual mass (or partial pressure) of water vapour in a given volume of moist air to that in saturated air at the same temperature, $\phi = p_v/p_{vs}$.

Specific humidity (humidity ratio, ω): The mass of water vapour present per kg of dry air, $\omega = 0.622 p_v/(p - p_v)$ kg/kg of dry air.

(Each definition 1 M)

b) Cooling with dehumidification on psychrometric chart.

2 M



(i) Cooling & dehumidification

Air at state 1 passes over a coil colder than its dew point: DBT and ω both decrease ($1 \rightarrow 2$, downward to the left); moisture condenses and is drained.

(Sketch 1 M, explanation 1 M)

c) Functions of expansion device.

2 M

- Reduces the pressure of liquid refrigerant from condenser pressure to evaporator pressure.
- Controls (meters) the flow of refrigerant to the evaporator according to load.
- Maintains the pressure difference between high and low sides of the system.
- Keeps the evaporator properly fed and prevents liquid flooding back to compressor (TEV).

(Any four, $\frac{1}{2}$ M each)

d) Ventilation and infiltration.

2 M

Ventilation: The intentional supply of fresh outdoor air into a space and removal of stale air, either naturally (windows, stack effect) or mechanically (fans), to maintain air quality.

Infiltration: The uncontrolled (unintentional) leakage of outdoor air into a building through cracks, gaps around doors and windows and opening of doors, due to wind and stack pressure.

(Each definition 1 M)

e) Sources of latent heat gain.

2 M

- Occupants — moisture from respiration and perspiration.
- Infiltration air (outside air leaking in with higher humidity).
- Ventilation (fresh) air brought in through the AHU.
- Cooking, coffee machines, steam tables, hot water baths and other moisture-producing appliances/processes; wet floors.

(Any four, ½ M each)

f) Tonne of refrigeration and COP.

2 M

One tonne of refrigeration (TR): the rate of heat removal required to freeze one tonne (1000 kg) of water at 0 °C into ice at 0 °C in 24 hours. In practice 1 TR = 211 kJ/min = **3.517 kW**.

COP: the ratio of refrigerating effect (heat removed) to the work (energy) supplied, $COP = Q_2/W$.

For a heat pump $COP_{HP} = Q_1/W = COP_R + 1$.

(Each definition 1 M)

g) Advantages of split AC over window AC.

2 M

- Quiet in the room — compressor and condenser fan are outside.
- No window or large wall opening needed; better appearance; flexible indoor location.
- Better air throw and distribution; available in higher capacities and inverter models.
- Outdoor unit can be placed where condenser gets good air flow — better efficiency.

(Any four, ½ M each)

Q.2

a) Open type compressor — advantages and disadvantages over hermetic.

4 M

Advantages of open type over hermetic:

- Can be dismantled and repaired at site; parts replaceable.
- Speed can be changed by changing pulley — capacity control.
- Can be used with any refrigerant including ammonia (motor not in contact with refrigerant).
- Available in large capacities; motor can be engine/turbine driven.

Disadvantages:

- Refrigerant leakage through the shaft seal.
- Bulky, heavier, more noise; belt/coupling alignment needed.
- Needs regular maintenance (seal, belt, lubrication) — higher maintenance cost.
- Motor is not cooled by refrigerant; larger space required.

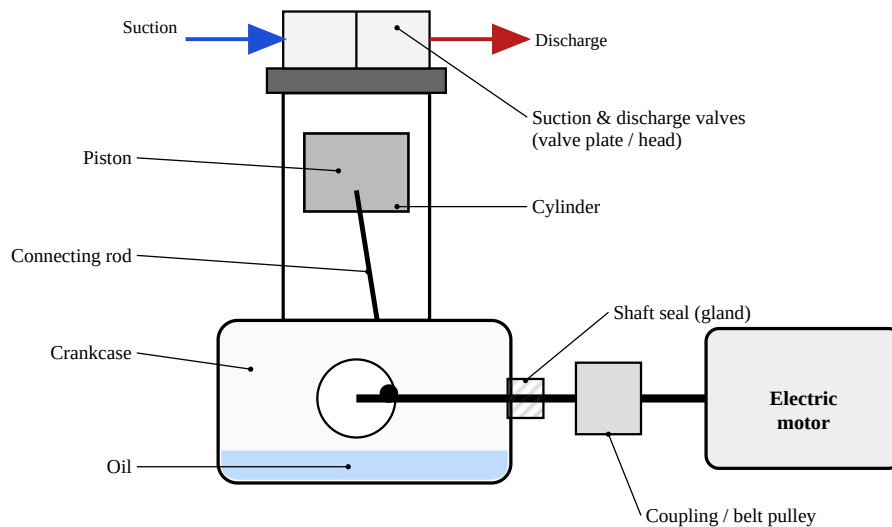
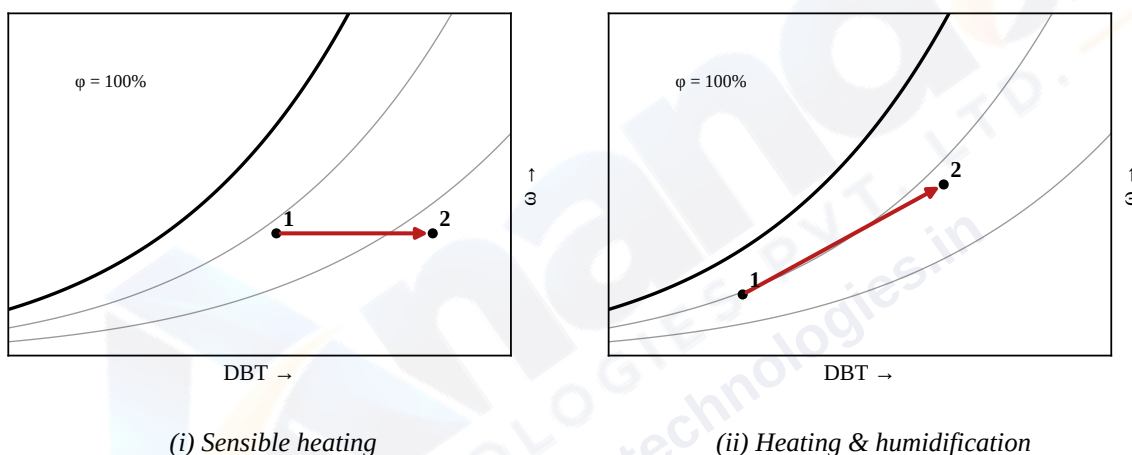


Fig.: Open type reciprocating compressor (externally driven)

(Advantages 2 M, disadvantages 2 M)

b) Sensible heating and heating with humidification on chart.

4 M



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 = $m(h_2 - h_1) = m c_{pa}(t_2 - t_1)$, $c_{pa} \approx 1.022 \text{ kJ/kg K}$ for humid air.

Heating and humidification (1–2): Air is heated and moisture is added (heating coil + steam/water spray). DBT and ω both increase; line goes upward to the right. Used in winter air-conditioning.

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

c) Flooded type evaporator and applications.

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**.

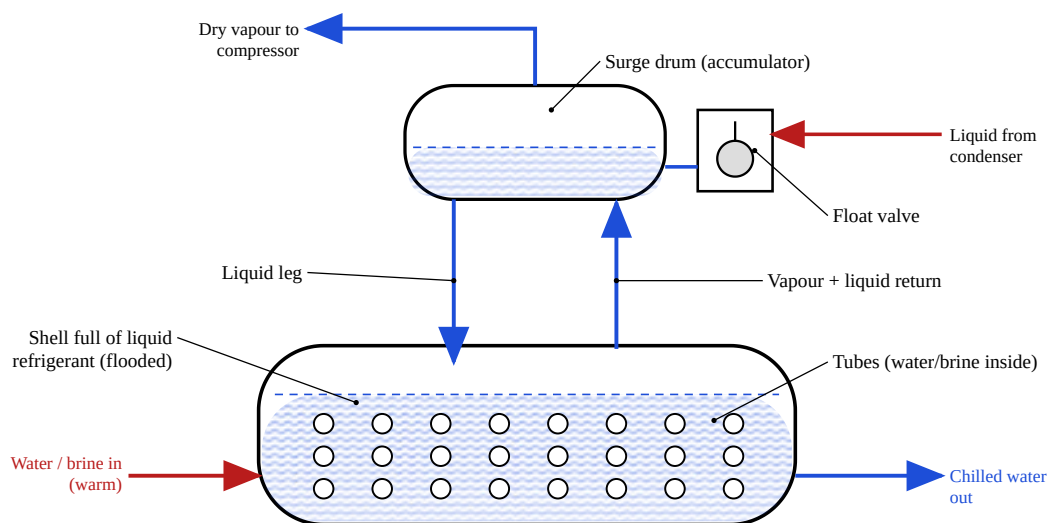


Fig.: Flooded type (shell and tube) evaporator with surge drum and float valve

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.

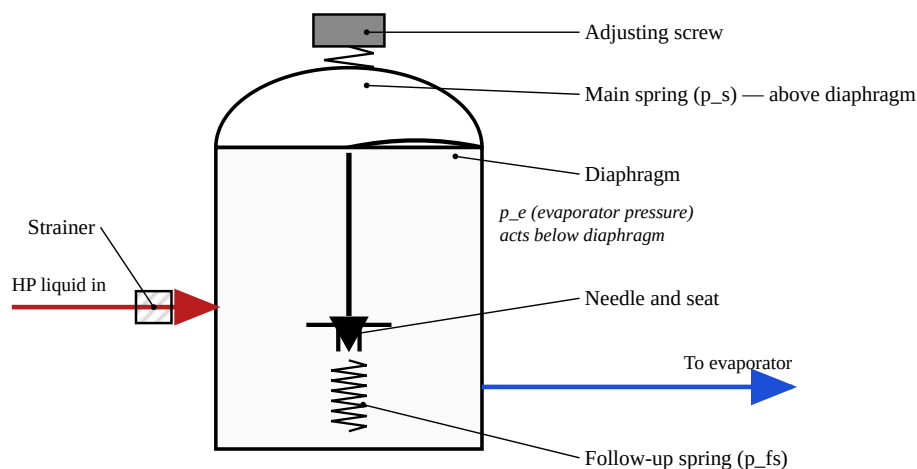
Applications: large water/brine chillers, ammonia plants, ice plants.

(Sketch 2 M, working 2 M)

d) Automatic expansion valve.

4 M

The **automatic expansion valve (AEV)** maintains a **constant evaporator pressure** irrespective of load.



$$\text{Balance: } p_s = p_e + p_{fs} \rightarrow \text{keeps evaporator pressure constant}$$

Fig.: Automatic (constant pressure) expansion valve

Working: Main spring pressure p_s acts above the diaphragm (tends to open); evaporator pressure p_e and follow-up spring p_{fs} act below (tend to close). If evaporator pressure falls below the set value (compressor running, low load), the main spring pushes the diaphragm down and opens the valve, admitting more refrigerant till pressure rises again. If p_e rises, the valve closes. Setting is changed by the adjusting screw.

Use: small units with nearly constant load (domestic freezers, ice-cream cabinets). It overfeeds at low load and starves at high load, so not used for varying loads.

(Sketch 2 M, working 2 M)

Q.3

a) Insulating materials and their properties.

4 M

Insulating materials: (1) expanded polystyrene (thermocole) (2) polyurethane foam (PUF) (3) glass wool (4) mineral/rock wool (5) nitrile rubber foam (6) cork.

Desirable properties:

- Low thermal conductivity ($k \approx 0.02\text{--}0.05 \text{ W/m K}$).
- 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.

(Materials 2 M, any four properties 2 M)

b) Split air conditioner.

A **split air conditioner** has two parts: an **indoor unit** (evaporator + blower) in the room and an **outdoor unit** (compressor + condenser + fan) outside, connected by insulated copper refrigerant pipes and a cable.

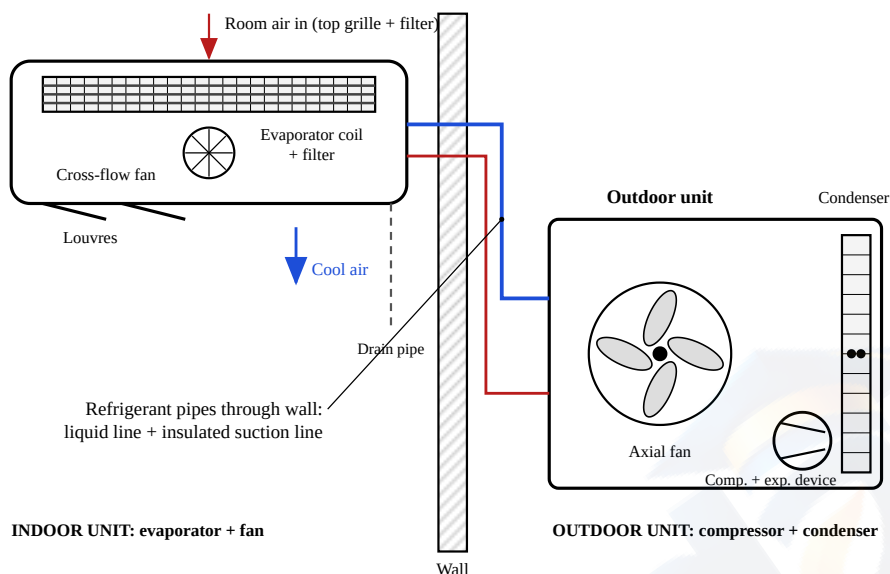


Fig.: Split air conditioner (wall-mounted indoor unit + outdoor unit)

- Indoor unit: room air enters through the top grille and filter, passes over the evaporator coil, is cooled and dehumidified and is blown back by a cross-flow fan through louvres.
- Outdoor unit: hermetic/rotary compressor raises refrigerant pressure; the condenser rejects heat to outside air moved by an axial fan; expansion device (capillary / EEV) feeds the indoor coil.
- Condensate is drained by a drain pipe.
- Advantages over window AC: silent indoor unit (compressor is outside), better appearance, no window opening needed, flexible location; inverter models save energy.

(Sketch 2 M, explanation 2 M)

c) Central vs unitary AC system.

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) Occupant load and lighting 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: $Q_s = N \times \text{SHG per person}$; $Q_L = N \times \text{LHG per person}$; where N = number of occupants (from seating capacity or floor area $\div$ 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): $Q_s = 60 \times 75 = 4500 \text{ W}$; $Q_L = 60 \times 55 = 3300 \text{ W}$; total occupant load = 7.8 kW.

Lighting load: $Q = \text{total wattage of lamps} \times \text{use factor} \times \text{allowance factor}$. Allowance (ballast) factor = 1.25 for fluorescent tubes (ballast loss), 1.0 for incandescent; for LED use driver loss ≈ 1.1 . Example: 20 tubes of 40 W $\rightarrow 20 \times 40 \times 1.25 = 1000 \text{ W}$ (all sensible).

(Occupant load 2 M, lighting load 2 M)

Q.4

a) Water cooled shell and tube condenser.

4 M

A **shell and tube water-cooled condenser** consists of a cylindrical steel shell containing many straight water tubes fixed in tube plates at both ends, with water boxes (heads) bolted on the ends.

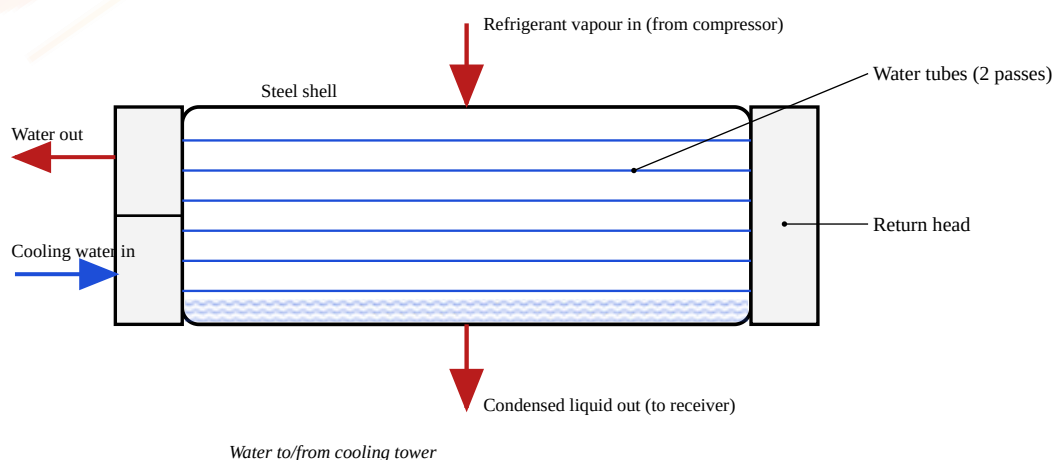


Fig.: Water cooled shell and tube condenser

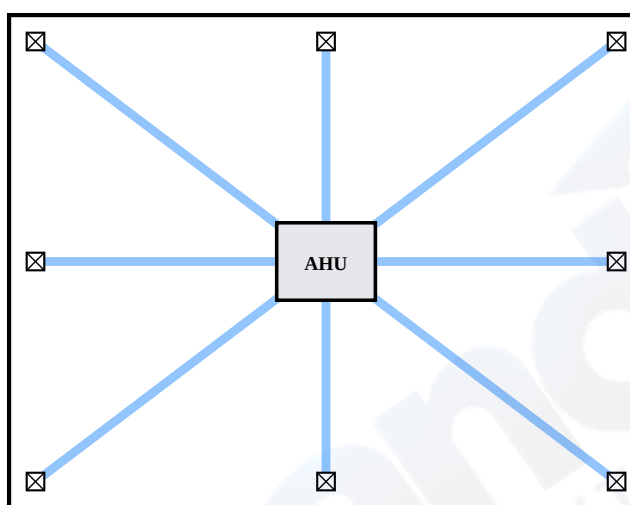
- Cooling water from the cooling tower is pumped through the tubes (2 or 4 passes).
- Hot refrigerant vapour enters the shell from the top and condenses on the outside of the cold tubes.
- The condensed liquid collects at the bottom of the shell (which also acts as a receiver) and goes to the expansion valve.
- Heated water returns to the cooling tower, is cooled and re-circulated.

Applications: large central AC plants, water chillers, cold storages (above ≈ 20 TR).

(Sketch 2 M, working 2 M)

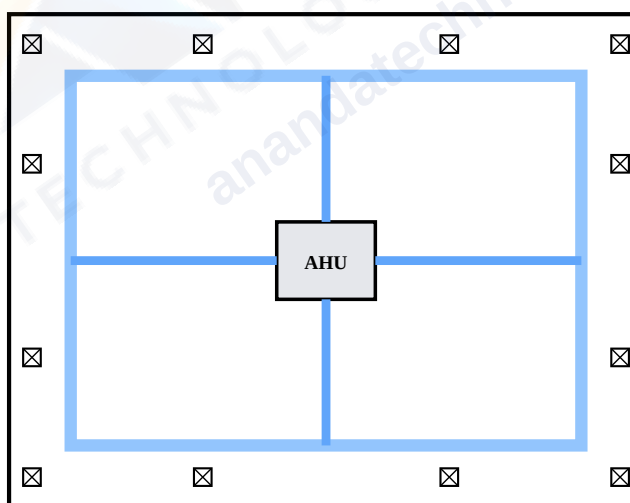
b) Radial and perimeter loop duct systems.

4 M



Ducts run straight from the unit to outlets at the perimeter

(a) Radial duct system



Loop duct under the floor slab feeds outlets along outer walls

(b) Perimeter loop system

- **Radial system:** the AHU/furnace is placed at the centre and separate round ducts run radially (straight) to supply outlets near the outer walls. Used in small single-storey houses with central plant — short ducts, few fittings, low cost.

- **Perimeter loop (closed perimeter) system:** a loop duct is laid around the perimeter (usually under the floor slab) and fed by feeder ducts from the central unit; outlets are located along the outer walls. Gives uniform warm/cool air along walls and floor — used in buildings on slab floors in cold climates.
- Both supply the air near outside walls where load is highest; return air is taken through central return grilles.

(Sketches 2 M, explanation 2 M)

c) Dampers and filters.

4 M

Dampers are movable plates/blades in ducts used to control (balance) the quantity of air or to shut off flow, and to mix fresh and return air.

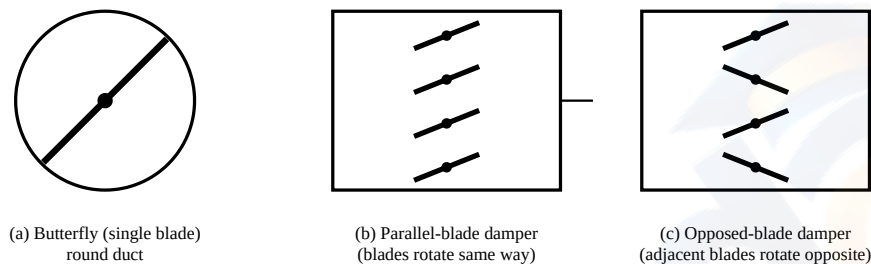


Fig.: Dampers — (a) butterfly (b) parallel-blade (c) opposed-blade

Types: butterfly (single blade), parallel-blade and opposed-blade multi-louvre dampers, splitter damper (at branch), fire damper (closes automatically by fusible link), motorised dampers (VAV).

Filters remove dust, pollen, smoke and bacteria from air: (i) viscous impingement (oil-coated) panel filters; (ii) dry pleated / bag filters (fibre glass, synthetic); (iii) HEPA filters (99.97 % at 0.3 μm) for OTs and clean rooms; (iv) electrostatic precipitators; (v) activated carbon filters for odour.

(Dampers 2 M, filters 2 M)

d) Car air conditioning system layout.

4 M

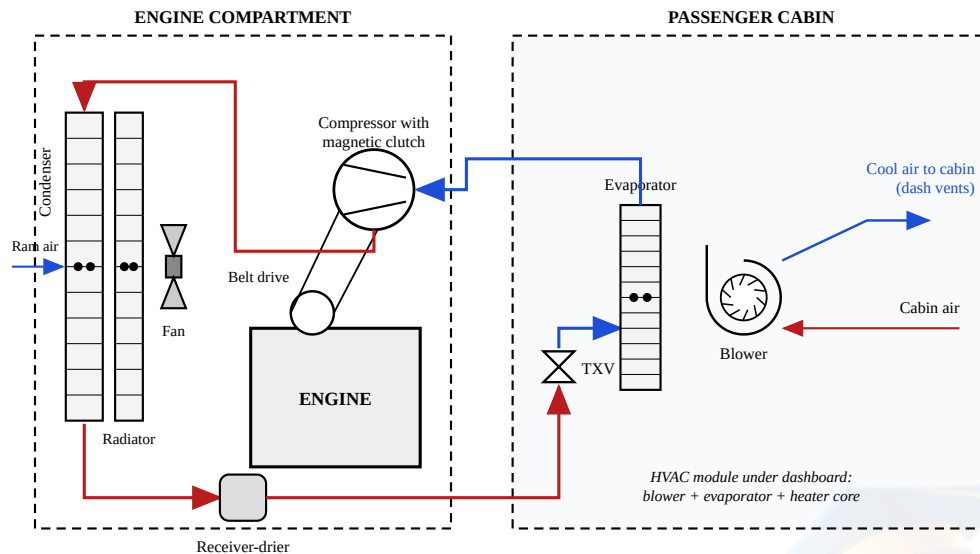


Fig.: Layout of automobile (car) air conditioning system

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)

e) Natural and mechanical ventilation.

4 M

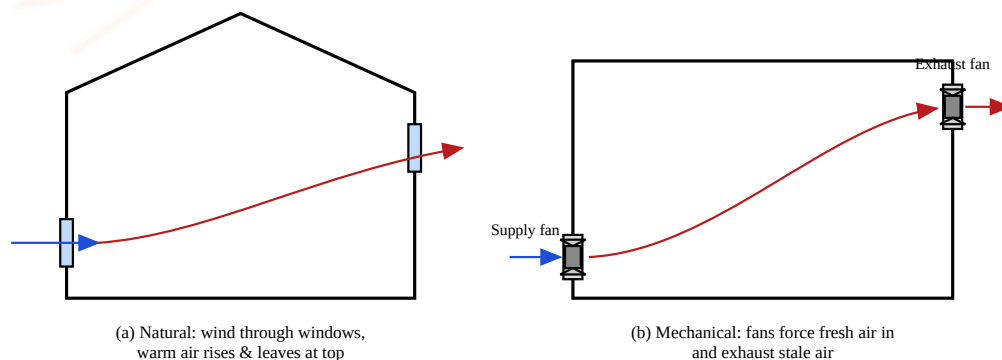


Fig.: (a) Natural (cross / stack) ventilation (b) Mechanical ventilation

Natural ventilation: air movement is caused by natural forces — (i) **wind effect**: wind pressure on windward side pushes air in and suction on leeward side draws it out (cross ventilation); (ii) **stack**

effect: warm, light inside air rises and leaves through high openings while cool air enters at low openings. Cheap, no energy, but not controllable.

Mechanical ventilation: fans are used — (i) supply (plenum) system: fan forces air in, room under slight positive pressure; (ii) exhaust system: fan removes air (toilets, kitchens); (iii) balanced system: both supply and exhaust fans (auditoriums, basements). Controllable and reliable but consumes power.

(Sketch 1 M, natural 1.5 M, mechanical 1.5 M)

Q.5

a) Adiabatic mixing of two air streams.

6 M

Given: Stream 1: 30 m³/min at 35 °C DBT, 50 % RH; Stream 2: 70 m³/min at 25 °C DBT, 50 % RH; p = 101.325 kPa.

Formulas used (p = 101.325 kPa; saturation pressures from steam tables):

$$p_v = \phi \cdot p_{vs} \quad \omega = 0.622 p_v / (p - p_v) \quad h = 1.005 t + \omega(2500 + 1.88 t) \text{ kJ/kg d.a.}$$

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

Mixing is adiabatic, so mass of dry air, moisture and energy are conserved: $m_1\omega_1 + m_2\omega_2 = (m_1+m_2)\omega_3$ and $m_1h_1 + m_2h_2 = (m_1+m_2)h_3$.

State	p_{vs} (kPa)	p_v (kPa)	ω (kg/kg)	h (kJ/kg)	v (m ³ /kg)	$m = V/v$ (kg/min)
1	5.6290	2.8145	0.0178	80.77	0.8978	33.42
2	3.1699	1.5850	0.0099	50.30	0.8579	81.59

$$\omega_3 = (33.42 \times 0.0178 + 81.59 \times 0.0099)/(33.42 + 81.59) = \mathbf{0.0122 \text{ kg/kg d.a.}}$$

$$h_3 = (33.42 \times 80.77 + 81.59 \times 50.30)/(115.01) = \mathbf{59.15 \text{ kJ/kg d.a.}}$$

$$t_3 \text{ from } h_3 = 1.005 t_3 + \omega_3(2500 + 1.88 t_3): t_3 = (59.15 - 2500 \times 0.0122)/(1.005 + 1.88 \times 0.0122) = \mathbf{27.94 \text{ }^\circ\text{C}}$$

$$\text{RH}_3: p_{v3} = 1.9454 \text{ kPa, } p_{vs}(27.9 \text{ }^\circ\text{C}) = 3.7688 \text{ kPa} \rightarrow \phi_3 = \mathbf{51.6 \%}$$

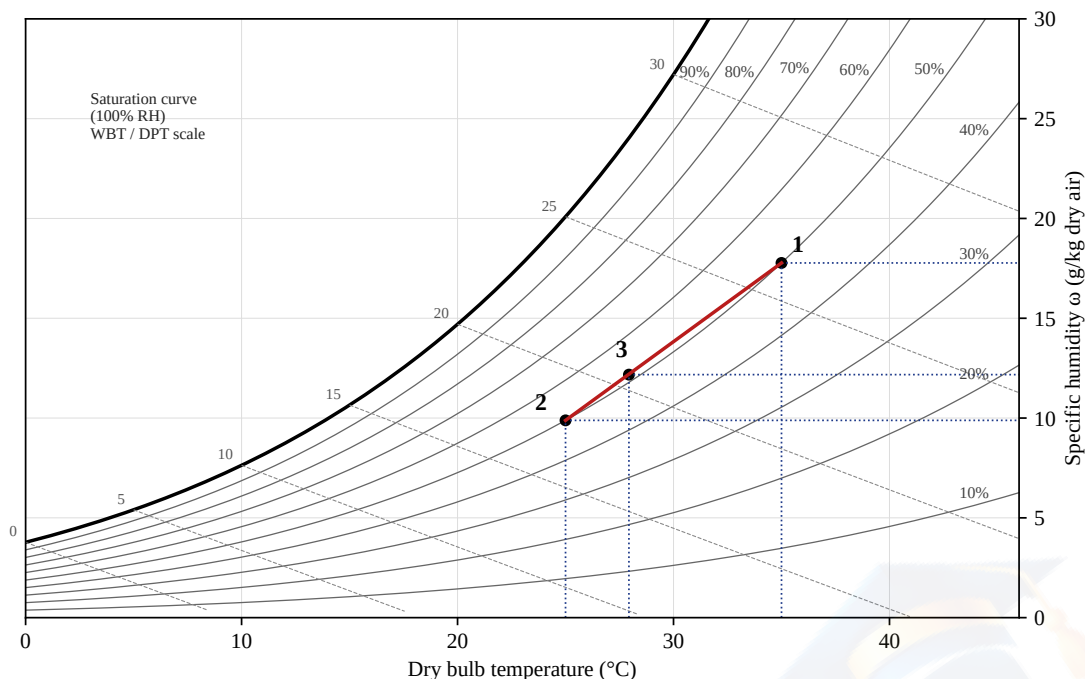


Fig.: Adiabatic mixing — mixture point 3 lies on line 1–2; $2-3 : 3-1 = m_1 : m_2$

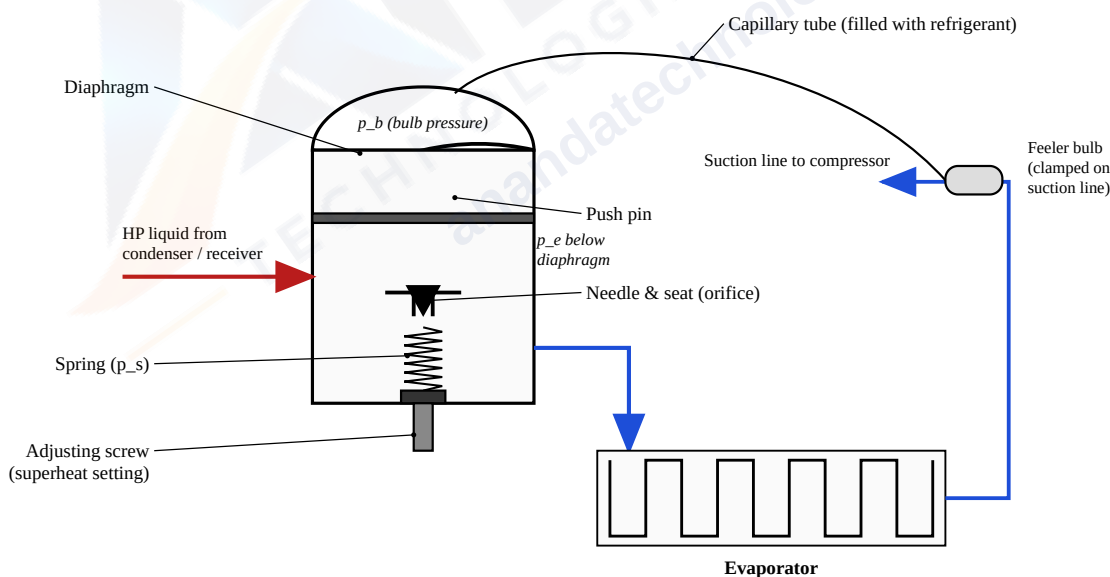
Condition after mixing: DBT = 27.94 °C, $\omega = 0.0122$ kg/kg d.a., $h = 59.15$ kJ/kg d.a., RH $\approx$ 51.6 %, WBT $\approx$ 20.6 °C

(Properties of streams 2 M, mixture ω and h 2 M, DBT & RH 1 M, chart 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 $\rightarrow p_b$ rises $\rightarrow$ 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/package 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.

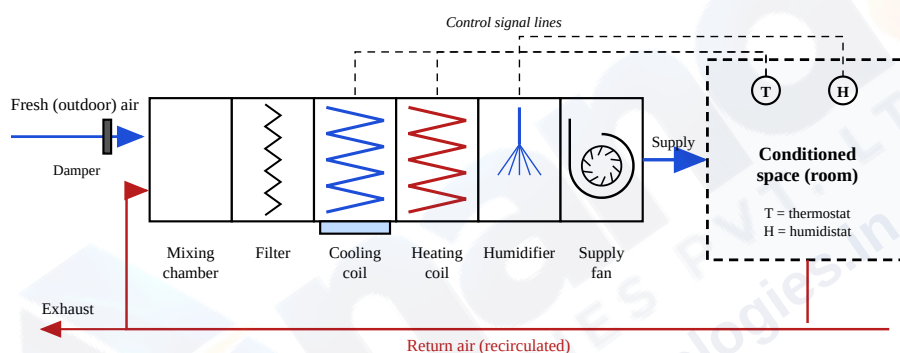


Fig.: Year-round air conditioning system

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) Sources of heat gain; cooling load of a seminar hall.

6 M

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 ($\times 1.25$ 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.

Sources of latent heat gain: occupants (respiration and perspiration), infiltration and fresh air moisture, cooking/kettles, steam from processes, wet floors.

Assumed data: persons seated, very light work — 70 W sensible, 45 W latent each; wall & glass $\Delta T = 40 - 25 = 15^\circ\text{C}$; fresh air 5 L/s per person; infiltration 0.5 air change/h; $\rho = 1.2 \text{ kg/m}^3$; safety factor 10 %.

Room data (assumed): $15 \text{ m} \times 10 \text{ m} \times 4 \text{ m}$ (volume 600.0 m^3). Outside design: 40°C DBT, 35 % RH ($\omega_o = 0.0163 \text{ kg/kg}$); inside design: 25°C DBT, 50 % RH ($\omega_i = 0.0099 \text{ kg/kg}$) — ω from $\omega = 0.622p_v/(p - p_v)$.

Source of heat gain	Calculation	Sensible (W)	Latent (W)
Roof (equivalent ΔT)	$Q = U A \Delta T = 1.1 \times 150.0 \times 20$	3300	—
Exposed walls	$Q = U A \Delta T = 1.8 \times 60.0 \times 15$	1620	—
Glass (conduction)	$Q = U A \Delta T = 5.8 \times 10.0 \times 15$	870	—
Solar gain through glass	$A \times q_{\text{solar}} = 10.0 \times 150 \text{ W/m}^2$	1500	—
Occupants (100 persons)	$SH = 100 \times 70 \text{ W}$; $LH = 100 \times 45 \text{ W}$	7000	4500
Lighting (fluorescent)	$1200 \text{ W} \times 1.25$ (ballast factor)	1500	—
Audio-visual equipment	$1 \times 1000 \text{ W}$	1000	—
Infiltration (0.5 air change/h)	$\dot{V} = 0.0833 \text{ m}^3/\text{s}$, $\dot{m} = 1.2 \dot{V} = 0.1000 \text{ kg/s}$ $SH = \dot{m} \times 1.0216 \times (40 - 25)$ $LH = \dot{m} \times 2500 \times (0.0163 - 0.0099)$	1532	1599
Ventilation (fresh) air 5 L/s per person	$\dot{V} = 0.5000 \text{ m}^3/\text{s}$, $\dot{m} = 1.2 \dot{V} = 0.6000 \text{ kg/s}$ $SH = \dot{m} \times 1.0216 \times (40 - 25)$ $LH = \dot{m} \times 2500 \times (0.0163 - 0.0099)$	9194	9597
Sub-total		27517	15696

Add 10 % safety factor		30268	17266
------------------------	--	-------	-------

Total cooling load = 30268 + 17266 = **47535 W = 47.53 kW**. In tonnes of refrigeration (1 TR = 3.517 kW): **13.52 TR**. Room SHF = 30268/47535 = **0.64** → select a 14.0 TR unit (next standard size).

(Sources 2 M, calculation 3 M, result 1 M)

b) Rectangular duct — pressure loss, fan power, equivalent diameter.

6 M

Given: $a \times b = 0.5 \text{ m} \times 0.3 \text{ m}$, $L = 30 \text{ m}$, $Q = 1.2 \text{ m}^3/\text{s}$, $f = 0.005$, standard air $\rho = 1.2 \text{ kg/m}^3$.

Area $A = 0.5 \times 0.3 = 0.1500 \text{ m}^2$; perimeter $P = 2(0.5 + 0.3) = 1.60 \text{ m}$

Hydraulic mean depth $m = A/P = 0.1500/1.60 = 0.09375 \text{ m}$ (equivalent diameter $D_h = 4m = 0.3750 \text{ m}$)

Velocity $V = Q/A = 1.2/0.1500 = \mathbf{8.00 \text{ m/s}}$

Friction loss (Fanning / Darcy form): $\Delta p_f = f L \rho V^2 / (2 m) = 0.005 \times 30 \times 1.2 \times 8.00^2 / (2 \times 0.09375) = \mathbf{61.4 \text{ Pa}}$

Velocity pressure $p_v = \rho V^2 / 2 = 1.2 \times 8.00^2 / 2 = \mathbf{38.4 \text{ Pa}}$

Total pressure required at inlet $p_t = \Delta p_f + p_v = 61.4 + 38.4 = \mathbf{99.8 \text{ Pa}}$ (= 10.2 mm of water)

Air power = $Q \times p_t = 1.2 \times 99.8 = \mathbf{119.8 \text{ W}}$

Fan (shaft) power = air power/ $\eta = 119.8/0.65 = \mathbf{184.3 \text{ W}}$

(i) Equal velocity (same V and friction per metre): $D_e = 2ab/(a + b) = 2 \times 0.5 \times 0.3/(0.5 + 0.3) = \mathbf{0.375 \text{ m} = 375 \text{ mm}}$

(ii) Equal flow rate and equal friction (Huebscher): $D_e = 1.3 (ab)^{0.625}/(a + b)^{0.25} = 1.3 \times (0.1500)^{0.625}/(0.80)^{0.25} = \mathbf{0.420 \text{ m} = 420 \text{ mm}}$

Answers: (i) $\Delta p_f = 61.4 \text{ Pa}$ (ii) $p_t = 99.8 \text{ Pa}$ (iii) air power = 119.8 W, fan power = 184.3 W (iv) $D_e = 420 \text{ mm}$ (equal friction), 375 mm (equal velocity)

(Friction loss 2 M, total pressure 1 M, powers 1 M, equivalent diameters 2 M)

c) Summer AC for hot and dry outdoor conditions.

6 M

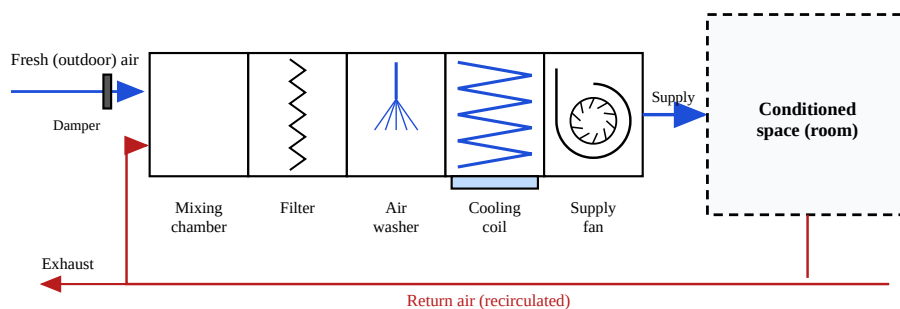


Fig.: Summer air conditioning for hot and dry outdoor conditions

- Outdoor air is hot and dry (low humidity, e.g. Rajasthan, Vidarbha).
- After mixing and filtering, air passes through an **air washer / evaporative (spray) section** which cools it and adds moisture (constant WBT process).
- If more cooling is needed, the **cooling coil** cools it further (sensible cooling); no dehumidification is needed.
- The fan supplies the conditioned air to the room; return air is re-circulated.
- Thus, for dry outdoor air, cooling with humidification is used instead of dehumidification.

(Sketch 3 M, explanation 3 M)

Note: This is a **model question paper prepared by Ananda Technologies** only for practice and exam preparation, based on the pattern of previous MSBTE question papers and the K-scheme syllabus. It is **not an official MSBTE paper**, and it does **not** mean that these questions will come in the exam. Answers follow standard textbook points; marks shown are indicative. Free for students — anandatechnologies.in