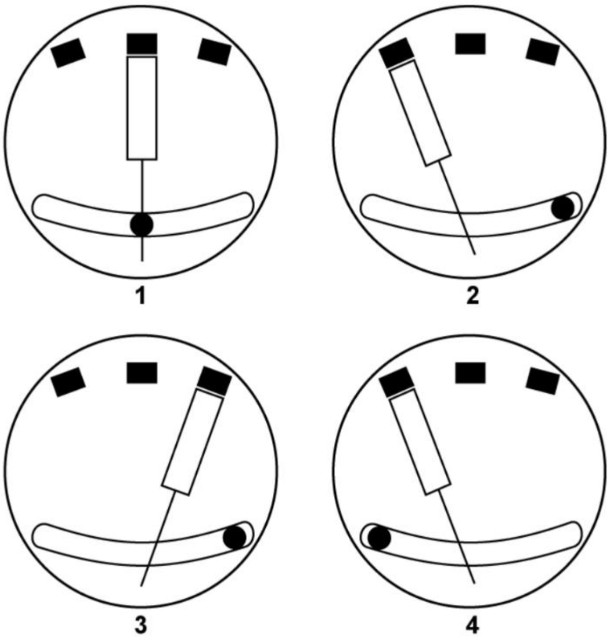
Instrumentation



Concerning the figure attached to the question:
#1 represents a straight & level flight.
#2 represents a skidding left turn (= too much left rudder/insufficient left bank)
#3 represents a slipping right turn (= insufficient right rudder/excessive right bank)
#4 represents a slipping left turn (= insufficient left rudder/excessive left bank)

Acceleration (ANDS) and Turning (UNOS) Errors

Acceleration errors: (ANDS => accelerate north, decelerate south)
• If the aircraft accelerates on westerly or easterly heading, the compass will indicate an apparent turn towards north;
• If the aircraft decelerates on westerly or easterly heading, the compass will indicate an apparent turn towards south;
• On a northerly or southerly heading the acceleration error is zero because the inertial force is in a north-south direction, i.e. along the magnet and thus, it will displace it neither clockwise, nor anti-clockwise. Error is ZERO when on a Northerly or Southerly heading

Turning errors: (UNOS => undershoot north, overshoot south)
• When the aircraft is turning through a northerly heading, the pilot must undershoot the target heading;
• When the aircraft is turning through a southerly heading, the pilot must overshoot the target heading;
• When turning through an easterly or westerly heading, the turning error is zero.
Error is ZERO when on an Easterly or Westerly heading
Note 1: *all of the info above is based on a Northern hemisphere. It is reversed in the Southern hemisphere.*

LSS (Local speed of Sound) = 38.95 x √temp (in Kelvin)

***C into *Kelvin = +273**

UNOS:

To calculate how much Over/Undershoot = $\dfrac{\textbf{Bank angle + Latitude}}{\textbf{2}}$

Table 11: Recommended Colours for Certain Features

Feature	Color
Warnings	Red
Flight envelope and system limits, exceedances	Red or Yellow/Amber as appropriate (see above)
Cautions, non-normal sources	Yellow/Amber
Scales, dials, tapes, and associated information elements	White *(1)*
Earth	Tan/Brown
Sky	Blue/Cyan
Engaged Modes/Normal Conditions	Green
Instrument landing system deviation pointer	Magenta
Divisor lines, units and labels for inactive soft buttons	Light Gray

Note (1) Use of the colour green for tape elements (for example airspeed and altitude) has also been found acceptable if the colour green does not adversely affect flight crew alerting.

(f) The following table depicts display features that should be allocated a colour from either Colour Set 1 or Colour Set 2.

Table 12: Recommended Colour Sets for Certain Display Features

Display Feature	Colour Set 1	Colour Set 2
Fixed reference symbols	White	Yellow *(1)*
Current data, values	White	Green
Armed modes	White	Cyan
Selected data, values	Green	Cyan
Selected heading	Magenta *(2)*	Cyan
Active route/flight plan	Magenta	White

Note (1) Use of the colour yellow for functions other than flight crew alerting should be limited and should not adversely affect flight crew alerting. Note (2) In Colour Set 1, magenta is intended to be associated with those analogue parameters that constitute "fly to" or "keep centred" type information.

Summary for Air-Driven Indicators:
- Acceleration => apparent climbing turn to the right;
- Deceleration => apparent descending turn to the left;
- Turn through 90° => apparent climb; under-indication of bank;
- Turn through 180° => apparent climb; correct bank indication;
- Turn through 270° => apparent climb; over-indication of bank;
- Turn through 360° => both pitch and roll indicated correctly.

All Nose-up (apparent climb) apart from full 360.

Under, Correct, Over (indication of bank)

Summary for Electrical-Driven Indicators:
- Acceleration => apparent climb
- Deceleration => apparent descent

GPWS mode call outs:

1: Send (Sinkrate/Pull up)
2: The (Terrain)
3: Drunk (Don't sink)
4: To (Too low terrain)
5: Go (Glideslope)
6: Buy (Bank angle)
7: Wine (Windshear)

GPWS Inputs:

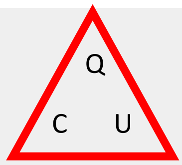
The inputs to the GPWS (Ground Proximity Warning System) are:
- ADC - Air Data Computer (speed, barometric altitude and vertical speed),
- CAS - Calibrated Air Speed,
- Glide slope deviation,
- Radio altimeter (radio altitude),
- NAV/ILS (Glide Slope),
- Flap position,
- Landing gear position.

*EASA questions assume advance **alert times of 40-60 seconds for the caution and 20-30 seconds for the warning**. These times appear to be based on average alert times of various manufacturers whose systems have demonstrated in flight testing to comply with the specified advance alert criteria from official regulations.*

Formulas

$C = e \times a \div d$

Capacitance (C) = dielectric permittivity (e) × area of plates (a) ÷ distance between plates (d)



**Some students reported that the formula appeared like this in their exams: C = e × (a ÷ d). The result will be the same therefore usually you do not add brackets.*

To find the charge (Q, Coulombs), we have to multiply the capacitance (C, Farads) by the potential difference (U, Volt) between the plates:

$Q = C \times U$

***The farad** (symbol: F) is the SI unit of capacitance. The unit is named after the English physicist Michael Faraday. A farad is the charge in coulombs which a capacitor will accept for the potential across it to change 1 volt. A coulomb is 1 ampere second. Example: A capacitor with capacitance of 47 nF will increase by 1 volt per second with a 47 nA input current.*

Proportionality

The formulas above show that:

The capacitance is directly proportional to the surface area of the plates (surface area increases => capacitance increases).

The capacitance is directly proportional to the relative permittivity (relative permittivity increases => capacitance increases).

The capacitance is inversely proportional to the distance between the plates (distance increases => capacitance decreases).

Gyros

Refer to figures 171 and 774.

Gyros are typically classified by the degree of freedom permitted of each type and by the plane in which the axis of the gyro is located:

Turn Indicator

The turn indicator or rate of turn indicator has a freedom in only 1 axis and the frame is supported by two return springs. The rotor spin axis is horizontal (parallel to the aircraft's lateral axis = pitch axis).

Artificial Horizon

The artificial horizon has a freedom in 2 axis. The rotor spin axis is vertical (parallel to the aircraft's vertical axis = yaw axis).

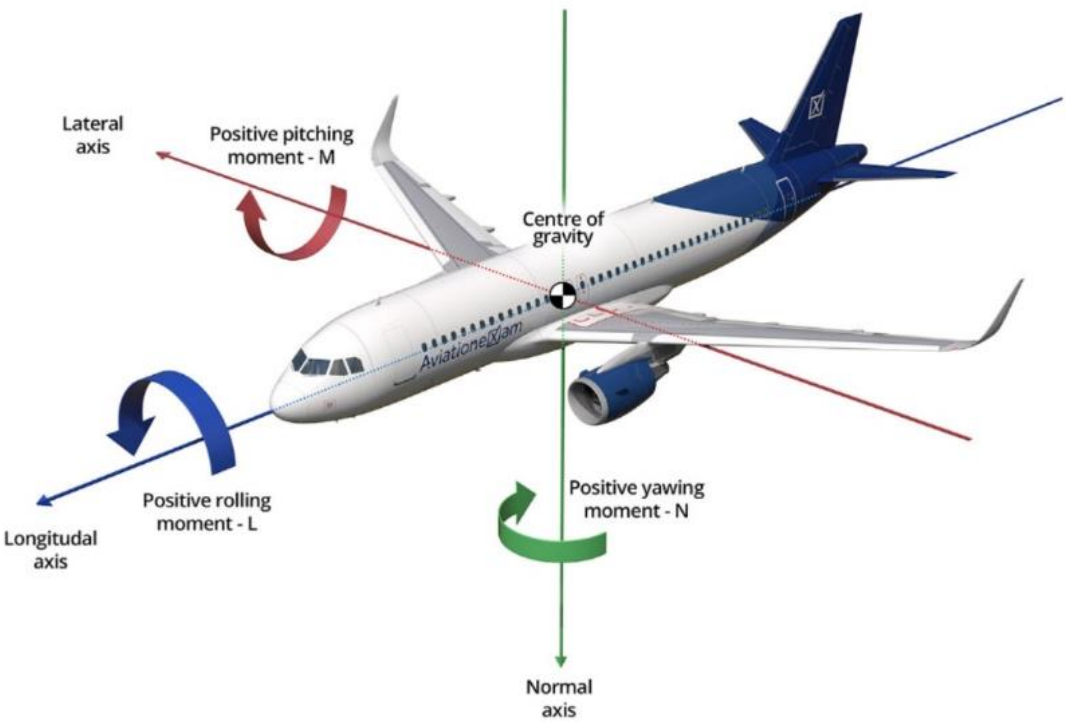
Directional Gyro Indicator

The directional gyro indicator or DGI has a freedom in 2 axis. The rotor spin axis is horizontal. In some questions EASA uses the term "gyromagnetic compass system" as a synonym for a slaved DGI (remote indicating compass system with a slaved Directional Gyro Indicator as the indicator unit).

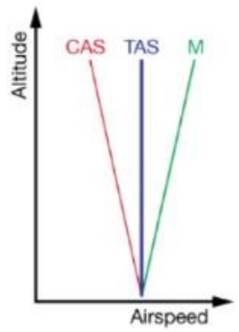
***Æ note**: the degree(s) of freedom of a gyro does not take into account its rotor spin axis according to the official Learning Objectives:*

022 04 01 00 Define the degrees of freedom of a gyro

Remark: As a convention, the degrees of freedom of a gyroscope do not include its own axis of rotation (the spin axis).



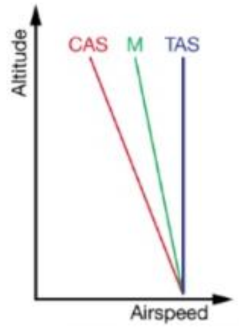
Standard Atmosphere



E C T M

(Eat Chicken Tikka Masala)

Inversion Layer



EMF = constant × hot junction temperature

E = K x T

Computers: (Processor is hardware)

> Mnemonic: MPH (Multiprocessing-Hardware) and MTS (Multitasking-Software).
> MPH (miles per hours) are bigger than MTS (meters per seconds).

Static Air Temp:
(M = Mach)

SAT = TAT ÷ (1+0.2 M^2).

$T_S = T_T \div (1+0.2 \times M^2)$

Calculation of Rate of Turn

A rate one turn is 180° a minute or 3° a second.

A rate two turn is twice that, 360° a minute or 6° a second.

A rate three turn is three times as much, 540° a minute or 9° a second.

The angle of bank required to achieve a given rate of turn increases with the TAS.

A useful formula to calculate the bank angle in degrees for Rate 1 turns is:

Angle of bank = TAS/10 + 7

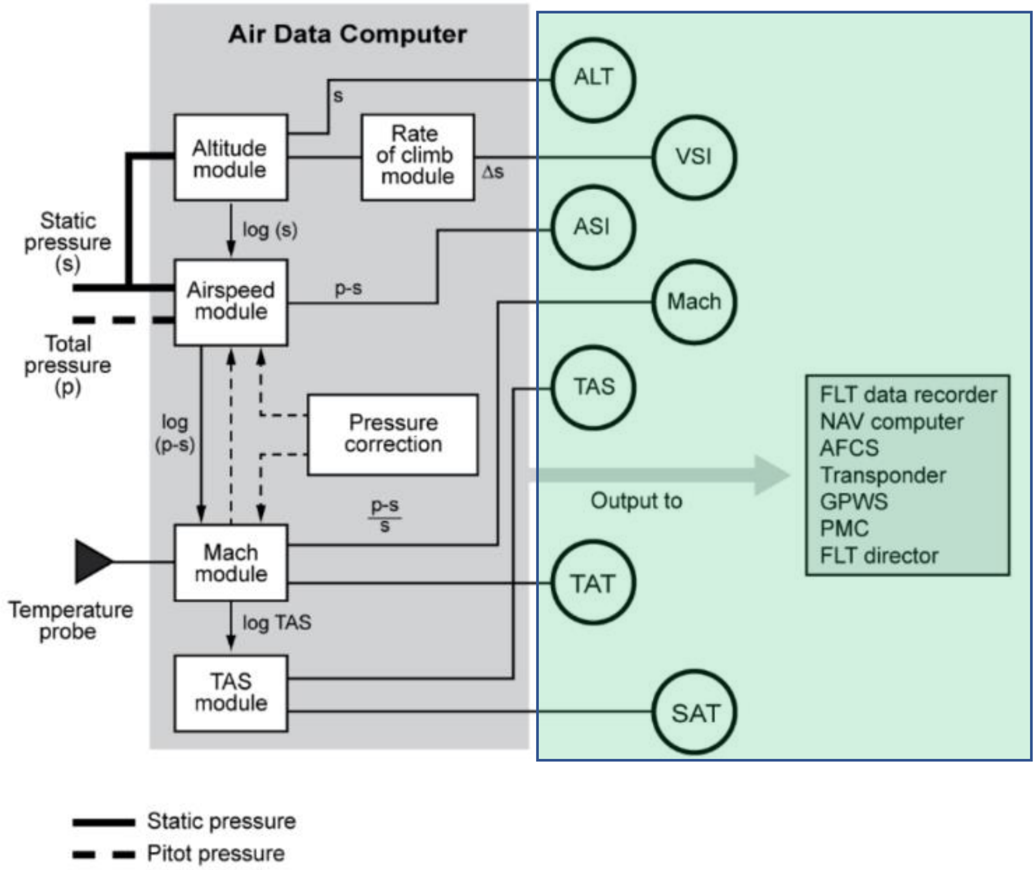
Questions relate to UNOS. Eg. Rate one turn after 30 seconds what will the heading read if intial heading is 330* turning Right

Aircraft 1 (TCAS II)	Aircraft 2 (TCAS II)	TCAS II functions available
Mode C or S	Transponder INOP	none - Aircraft 2 is "invisible" to
Mode C or S	Mode A	Traffic Advisory (TA) only
Mode C or S	Mode C or S	Traffic Advisory (TA) Resolution Advisory (RA)

1 autopilot = FAIL PASSIVE
2 autopilots for autoland approach = FAIL PASSIVE
3 autopilots for autoland approach = FAIL OPERATIONAL

If you get a single (1) autopilot failure it will go down a tier.

Eg. 3 autopiltos = Fail Operational. One fails it becomes Fail Passive



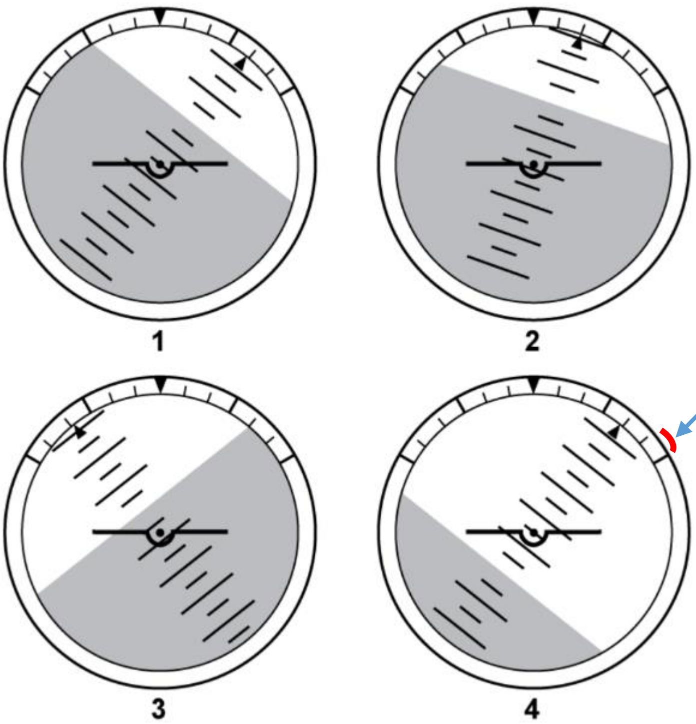
INNER Loop = Stabilisation

OUTER Loop = Aircraft Guidance

EICAS = Engine-Indicating and Crew-Alerting System

PFD and ND (737):

http://www.b737.org.uk/flightinstsmax.htm#nd



#1 shows 40° left bank and 15° nose down
#2 shows 20° left bank and 18° nose down
#3 shows 40° right bank and 8° nose down
#4 shows 40° left bank and 15° nose up

Each "segment" is 10* of bank

Conversion between these scales:
- °C = 5/9 × (°F - 32)
- °F = 1.8 × °C + 32
- °C = K - 273
- K = °C + 273

Pressure Sensors:

Bourdon – Highest Pressure
Bellows – Medium Pressure
Aneroid – Low Pressure

TCAS II Warnings:

Non-Threat (other) Aircraft
- White or cyan/blue open diamond shape (lozenge)
- Within ± 2 700 ft

Proximate Aircraft
- White or cyan/blue solid (full) diamond shape (lozenge)
- Within ± 1 200 ft and 6 NM

Threat Aircraft - Traffic Advisory (TA)
- Yellow or Amber solid (full) circle
- 35-45 seconds from a collision

Threat Aircraft - Resolution Advisory (RA)
- Red solid (full) square
- 20-30 seconds from a collision

Integrations:

Summary of integrations:

Speed:
- Integrate once the acceleration in time

INSTANTANEOUS speed:
- Integrate once the acceleration in time
- Know initial speed only

Distance:
- Integrate twice the acceleration in time

OR
- Integrate once the speed in time

INSTANTANEOUS position:
- Integrate twice acceleration in time OR once the speed in time
- Know initial position
- Know initial speed

INS alignment = 15 - 20 mins

IRS alignment = 3 – 10mins

INS = 3 Gyros, 2 Accelerometers

IRS = 3 Gyros, 3 Accelerometers

(IRS is just 3s across the board. 3Gyro, 3Accelerometers and 3mins)

Constant MACH, Decrease in OAT:

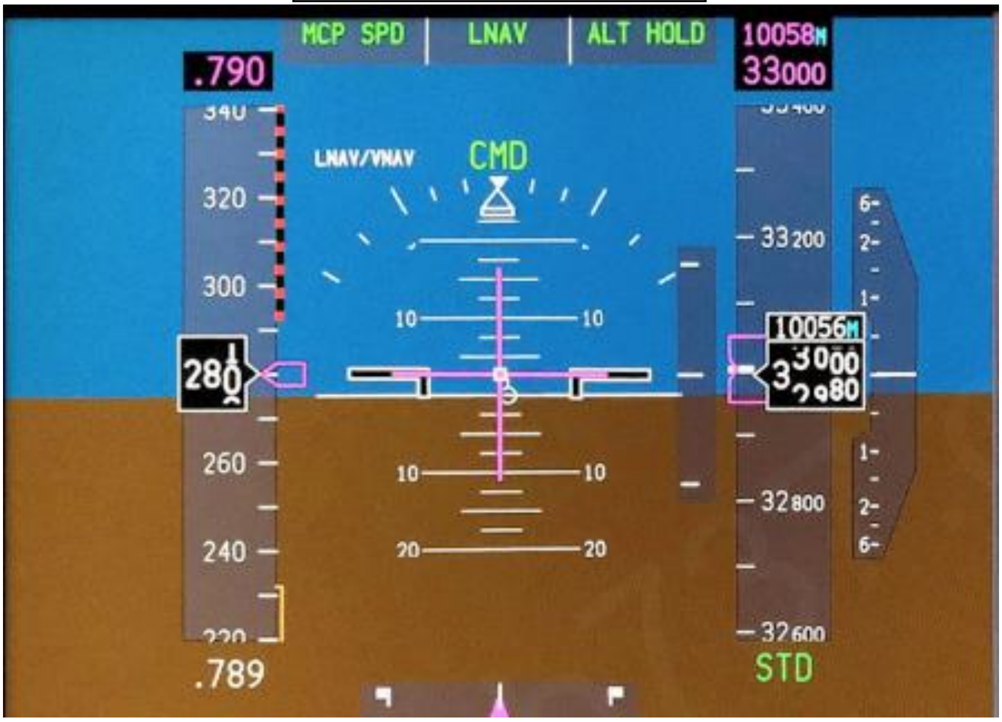
Therefore, if the temperature decreases, the LSS decreases. We know that Mach number = TAS ÷ LSS, therefore in order to maintain the same Mach number with a lower value of LSS, the TAS must decrease. With a constant Mach number, the TAS decreases. It would be quite the opposite with a temperature increase => constant Mach number means an increased TAS, because of increased LSS.

ARC Vspeeds: Vso – Vfe = White arc (for example)

SOFE-SINO-NONE-NE

white-green-yellow-red

Primary Flight Display (PFD)



Navigation Display (ND)

Button 3: Selection of desired IAS or Mach, when speed intervention is active.

Button 2: Enabling automatic engagement of autothrottle in specified conditions.

Button 1: Display of crossbars indicating commands according to autopilot-selected modes on the PFD.

Instrument Degrees of freedom:

TL1= Turn indicator… Lateral axis… 1 degree

AV2= Artificial horizon… Vertical axis… 2 degree

DH2= Directional gyro… horizontal axis… 2 degree

Basic Gyro properties:

- **Rigidity in space**
- **Precession**

FMS Navigation Database contains:

- Regional magnetic variations,
- RADIO Aids (identifiers; positions; frequencies; types of aid; DME elevation etc.)
- Waypoints (ICAO identifier; type; etc.)
- En-route Airways (airway designator; outboard magnetic course, etc.)
- Airports (ICAO identifier; position; elevation; alternates; etc.)
- Runways (ICAO identifier; number; length; heading; threshold position; etc.)
- Airport Procedures (ICAO code; type; SID, STAR, ILS, RNAV; etc.)
- Company Routes (origin airport; destination airport; route number; details of SID, route, STAR, approach; etc.)

Mach is constant OAT change questions:

M = TAS/LSS

CAS = 1/2p * TAS (p = rho) *Rho = Density*

If M constant and T increases, LSS increases and so do TAS to keep M constant.

If the temperature increases, rho decreases (inversely proportionnal to T°C, unless you're climbing or descending)

So if p decreases and TAS increases, CAS is constant.

Apparent DRIFT:

Rate of apparent DRIFT in ° per hour = 15° × sin (latitude) **0* at the equator**

Apparent DRIFT = 15° × sin (90°⇒ poles) = 15 × 1= **15°/h**

⇒This answer is CORRECT - at the poles (90° of latitude), the rate of apparent drift is 15°/h.

Multi-processing (MP) = Hardware – *More than one task at a time*

Multi-tasking (MT) = Software – *One task at a time*

A processor is a component (hardware)

15psi / bar

Which way the compass card rotates in an ANDS situation:

1. Know ANDS for North Hemisphere (and SAND for South Hemisphere).
As a reminder, it means that when you Accelerate, the compass turns North and when you Decelerate, the compass turns South (A N D S).
The inverse happens in the South Hemisphere (but this time you have to use SAND).

2. On a sheet of paper, draw the compass as it appears in the plane (when you see North on the compass, you're heading North). In other terms:

---------S---------
--E---------W--
---------N---------

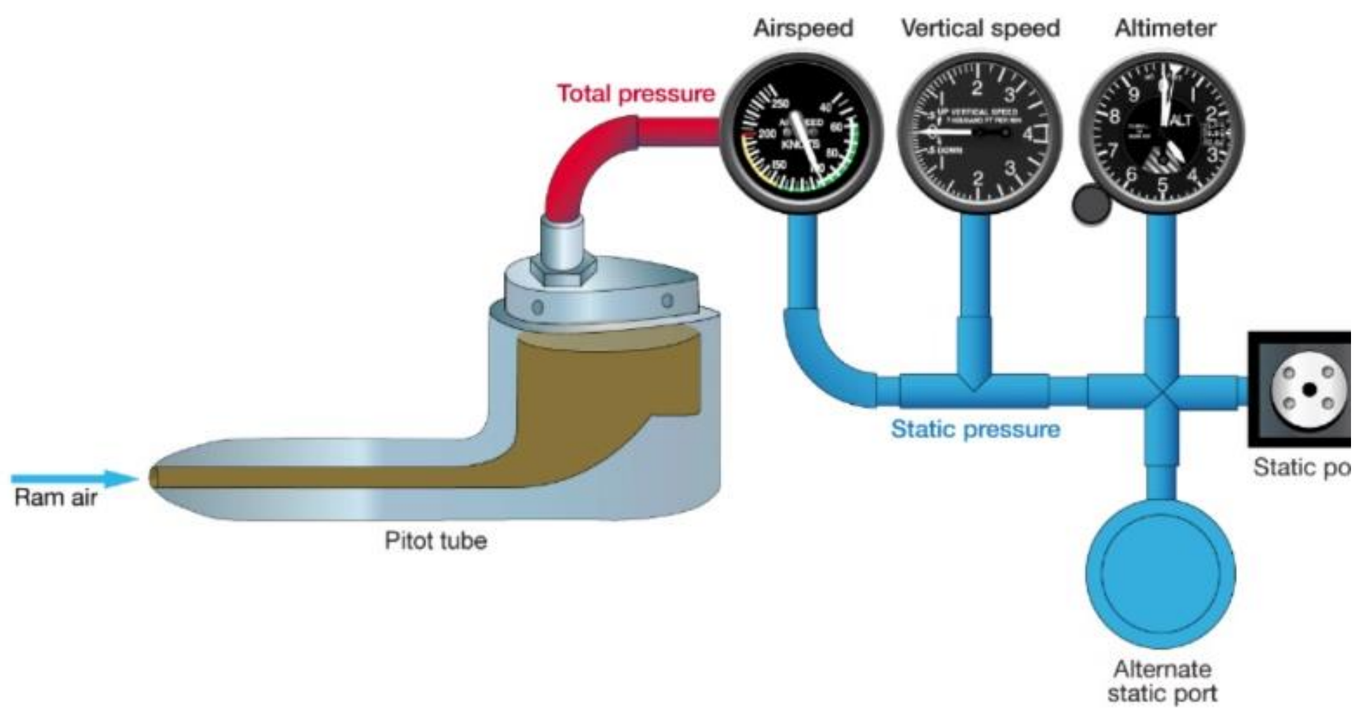
Point East (or given direction *E/W)

Another arrow toward North (or South) and rotate paper in direction to work out CW or CCW.

Now you're all set to solve the question.

Application:

BASIC PITOT-STATIC SYSTEM



Effect of blockage on	Airspeed	Altimeter	Vertical speed
Pitot source blocked.	Increases with altitude gain. Decreases with altitude loss.	Correct indication (not affected).	Correct indication (not affected).
Static source blocked.	Decreases with altitude gain. Increases with altitude loss.	Does not change ("freezes").	Returns to zero and does not change ("freezes on 0").
Both sources blocked.	All indications remain constant, regardless of actual changes in airspeed, altitude or vertical speed (all indicators freeze on the values at the time the blockage occurred).		

Warning = immediate recognition and corrective or compensatory action by the crew is required.
Caution = immediate crew awareness is required and subsequent crew action will be required.
Advisory = crew awareness is required and subsequent crew action may be required.
Message = a caption light or text on a display system providing information on an abnormality or aircraft condition.

Alert = a general signal to the crew intended to draw their attention to the existence of an abnormality, system fault or aircraft condition and to identify it.
False alert = an incorrect alert caused by a failure of the alerting system.

Mach No and CAS with differing Temp:

Lower temperature = lower LSS = higher MN at constant CAS
Lower temperature = higher density = lower TAS at constant CAS

Therefore the they cancel each other resulting in same MN

MNo is sensed by Dynamic/Static, or in other words CAS/Static. CAS remains the same, static pressure remains the same (steady cruise @FL270), therefor MNo remains the same