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Details of future “Workbook Workshops” can be found in Sharepoint on the Wing Calendar or contact the Wing Training Officer:

Training.ECSM@aircadets.org
TO USE THIS BOOK

Only essential knowledge and key revision points have been included in this manual. You must have a thorough knowledge of its contents before the examination.

Read each page, then read the questions and underline or highlight the correct answer. Revise the questions and answers as they may constitute a high proportion of the actual examination questions (typically 23 out of the 25 questions!).

Ensure your answers are correct before using them in your final revision.

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TAFs and METARs

Weather information is passed to aircrew by Terminal Aerodrome Forecasts (TAFs) and Meteorological Actual Reports (METARs). Standard codes are used for brevity.

The code CAVOK (cloud and visibility OK) means the visibility is at least 10 km and there is no cloud below 5000 ft.

TAF and METAR Decodes

BR Mist FZ Freezing SN Snow
DZ Drizzle TS Thunderstorm
HZ Haze FG Fog RA Rain
FU Smoke SH Shower
- Slight + Heavy

In the northern hemisphere, if you stand with your back to the wind, where is the higher pressure air?

a) On your left. b) In front of you. c) On your right. d) Above you.

Where on this pressure diagram will the wind speed be greatest?

a) A b) B c) C d) D

If the wind indicated by the isobars on a weather chart is 200 degrees / 20 kts, what would you expect the surface wind to be?

a) 175/15 b) 175/25 c) 230/15 d) 200/20

How does the met office pass information about airfield weather to aircrew?

a) By using TAFs and METARs. b) By television. c) By radar. d) By TEMPOs and BECMGs.

The main difference between a TAF and a METAR is:

a) One is a report, the other is a forecast. b) One TAF is more reliable. c) One never includes the wind velocity. d) One is for a longer time period than the other.

If you saw the term CAVOK in a weather report, what would it mean to you?

a) Visibility 5 km, cloud base 10,000 ft. b) Combat all-terrain vehicles OK. c) Visibility better than 5 km and no cloud below 10,000 ft. d) Visibility better than 10 km and no cloud below 5,000 ft.

In a TAF what would -SHSN mean?

a) Heavy snow. b) Snow all day. c) Sleet. d) Light snow showers.
What is the major variable in the atmosphere that affects weather?

a) Water in all its forms.  
b) Cigarette smoke.  
c) Pressure.  
d) Temperature.

What causes the air pressure at sea level?

a) Depression.  
b) The weight of the air above it.  
c) All the aircraft flying around.  
d) The movement of highs and lows on the weather chart.

When the temperature drops to the dew point, but is still above freezing, what kind of weather can you expect?

a) Fog.  
b) Rain.  
c) Sleet.  
d) Thunderstorms.

The 4 main reasons that air moves vertically are known as the trigger actions. What are these?

a) Convection, precipitation, thunderstorms, convection.  
b) Turbulence, convection, orographic and frontal uplift.  
c) Turbulence, convection, orographic, fiscal.  
d) Market forces, radiation, x-rays, frontal uplift.

What are clouds made of?

a) Visible droplets of water.  
b) Water vapour.  
c) Scotch mist.  
d) Steam.

What is the best thing for an aviator to do about thunderstorms?

a) Avoid them by a wide margin.  
b) Use the radar to go through the centre.  
c) Pass downwind of them.  
d) Stay on the ground.

What form of precipitation is commonest in thunderstorms?

a) Drizzle  
b) Snow  
c) Hail  
d) Showers

What do aircrew use to avoid thunderstorms?

a) Radio beacons.  
b) Seaweed.  
c) Radar.  
d) Weather forecasts.

Why must you be very careful if using an OS map to work out safety altitudes?

a) The map does not cover a large enough area.  
b) The map is out of date.  
c) The elevations are in metres.  
d) The grid is based on kilometre squares.

An aircraft is flying at 2000 ft above sea level, towards a hill whose peak is 1000 metres above sea level. If the pilot takes no action, will the a/c:

a) Hit the hill more than half way up the slope.  
b) Miss the hill by 1000 metres.  
c) Miss the hill by 1000 ft.  
d) Hit the hill near the peak.

The Navigator’s No 1 priority is:

a) Calculation of safety altitude.  
b) Keeping the a/c above safety speed.  
c) Navigating with a sextant.  
d) Calculating a/c altitude in metres.

The country which is changing to metric units most slowly in aviation is:

a) Russia  
b) USA  
c) UK  
d) France

What units of fuel would you expect to see on the gauges for meteorological reports?

a) Kilogrammes.  
b) U.S. Gallons.  
c) Imperial gallons.  
d) Pounds.

Why do we use units of volume for a/c fuel, even though it would be more correct to measure its mass?

a) It is impossible to weigh the fuel in the air.  
b) The Americans don’t like doing it that way.  
c) The mass of the fuel depends on its type.  
d) The fuel is affected by outside air temperatures.
**Fuel Conversion**

Different types of fuel each have a Specific Gravity (SG). This is a measure of the ratio between the weight of the fuel and the weight of the same volume of water. Water has an SG of 1.0; typically jet fuel has an SG of 0.8 - this means that a litre of jet fuel will weigh only 80% of the weight of a litre of water.

Conversion of fuel weight to volume, or between various types of units (lbs, kgs, gallons, litres etc) can be done on a calculator, a DR computer or using a chart in the RAF Flight Information Handbook.

**Pressure**

Atmospheric pressure is caused by the weight of the air above us.

The higher we go, the less air there is above us. Atmospheric pressure is greatest at sea level and reduces as we climb up through the atmosphere.

Pressure can be measured in pounds per square inch (psi), inches of mercury (the method used in the USA), in mm of mercury, or in millibars (mb).

**Millibars** are used everywhere outside the USA.

The average sea level pressure is 1013 millibars. The table below shows how the atmosphere thins with altitude:

<table>
<thead>
<tr>
<th>Altitude (feet)</th>
<th>Air Pressure (millibars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea level</td>
<td>1013</td>
</tr>
<tr>
<td>10,000</td>
<td>700</td>
</tr>
<tr>
<td>18,000</td>
<td>500</td>
</tr>
<tr>
<td>24,000</td>
<td>400</td>
</tr>
<tr>
<td>30,000</td>
<td>300</td>
</tr>
<tr>
<td>34,000</td>
<td>250</td>
</tr>
<tr>
<td>39,000</td>
<td>200</td>
</tr>
</tbody>
</table>

Note that at a commercial airliner’s typical cruising height of 34,000 ft, the air outside has only about one quarter of the air pressure at sea level. Consequently the amount of oxygen available is only one quarter of that at sea level. If it were not for the pressurisation system which maintains a higher air pressure inside the aircraft, those on board would lose consciousness.

If an a/c fuel tank was filled with water, it would contain 5000 pounds of water. If this water is now replaced with fuel at an SG of 0.80, how heavy would the fuel be?

a) 4000 pounds.
b) 400 gallons.
c) 8000 pounds.
d) 5000 pounds.

If the fuel tanker has its gauges calibrated in different units from the receiver aircraft fuel gauges, what method of conversion would the crew use?

a) A DR computer.
b) A fuel weight and volume conversion chart.
c) A calculator.
d) Any of the last three answers.

**Contrast and Colour**

Of the natural features used in map reading, rivers and coastlines are generally the most useful because they show the greatest contrast and colour change between themselves and the land.

**Map Scales**

Special maps are produced for map reading from the air. Emphasis is placed on features more easily identified from the air and the maps are made to a much smaller scale, typically 1:500,000.

**Timing Marks**

Before embarking on a flight in an aircraft without sophisticated navigation aids, a student will put timing or distance marks along each of the legs of his route. If he loses his place along his track he need only consult his watch, work out the time in minutes since the last waypoint, and that will tell him where to look on the map.
Radar Navigation

Airborne radar has been refined to such a stage that ground returns received by an aircraft are matched to a ‘computerised map’ enabling an accurate fix to be obtained simply at the press of a button.

One disadvantage of this system is that the radar transmissions can be detected by the enemy.

Long Range Fixing

During the 1950’s and 1960’s a number of long range ‘area’ navigation systems were developed (Gee, Decca, Loran and Omega). All worked on a similar principle, measuring the time it takes two synchronized signals to arrive from two different transmitting stations to give a fix.

Global Positioning System (GPS)

With airborne microcomputers and the network of Global Positioning satellites, it is now possible for even an unskilled operator to obtain fixes with accuracies of a few metres.

Active / Passive Systems

The development of radar-homing missiles has necessitated the development of even more sophisticated electronic warfare (EW) countermeasures. EW is a growth science and is the subject of a constant development race between nations.

EW measures are used to protect ‘active’ navigation systems, but another approach is to use only ‘passive’ systems. Passive systems do not transmit, merely receiving signals such as those transmitted by GPS satellites and combining that information with up to three inertial navigation systems (GPS + triple INS).

Conclusion

Despite the availability of very accurate navigation systems, a great deal of aviation training time is devoted to old fashioned methods such as map reading, particularly in a student’s early stages of training.

In the Tornado GR variants, a computer generated low level map can be superimposed over the radar picture. What does this enable the navigator to do?

a) Avoid carrying paper maps.  
b) Take quick, accurate fixes.  
c) Spot the golf courses he/she would like to play.  
d) Use look down, shoot down missiles.

What is the major disadvantage of radar in combat a/c?

a) It only works at night.  
b) You need a weapon systems operator to use it.  
c) It gives away your location.  
d) It only works at low level.

All long range nav aids work on a similar basis. What does the equipment use to calculate position?

a) Old Moore's Almanac.  
b) Time interval between synchronised signals.  
c) Time interval between successive fixes.  
d) Phase difference on various radials.

Only one long range Navigation System gives accuracies of about 100 metres. Which is it?

a) GEE.  
b) Decca.  
c) GPS.  
d) Loran.

What is the best defence against enemy detection of active navigation systems in fast jet a/c?

a) Use only astro navigation.  
b) Climb to service ceiling.  
c) Scramble/uns scramble the signals.  
d) Use only passive systems.

The best passive navigation system is:

a) Astro alone?  
b) Loran with astro?  
c) Triple inertial with GPS?  
d) Twin inertial with Omega?

In the early stages of training, students are made to concentrate on which method of navigation?

a) Astro navigation.  
b) Air plot.  
c) Map reading.  
d) Mechanical track plot.

In this diagram of the triangle of velocities, the vector with one arrow represents heading and true airspeed. The vector with two arrows represents track and groundspeed. Windspeed and direction is shown by the vector with three arrowheads.

Drift is the angle between the track and heading vectors.

Each vector constitutes two pieces of information, a direction, and a value indicated by the length of each arrow. As long as we have four of the elements of the vector triangle, we can find the other two. The solution can be found by a variety of methods, but the quickest is to use the Dalton DR Computer.

Flight Planning

In the world of the private pilot and light military trainers, flight planning is carried out using the Pilot Navigation Log Card.

In the triangle of velocities, which vector represents the wind velocity?

a) The angle between track and heading.  
b) The vector with one arrowhead.  
c) The vector with two arrowheads.  
d) The vector with three arrowheads.

In the triangle of velocities, which vector represents the track and groundspeed?

a) The longest one.  
b) The vector with two arrowheads.  
c) The vector with one arrowhead.  
d) The shortest one.

In the triangle of velocities, which vector represents the heading and airspeed?

a) The angle between track and heading.  
b) The vector with one arrowhead.  
c) The vector with two arrowheads.  
d) The vector with three arrowheads.

How is drift shown in the triangle of velocities?

In the Tornado GR variants, a computer generated low level map can be superimposed over the radar picture. What does this enable the navigator to do?

a) The angle between heading and wind direction.  
b) The angle between track and heading.  
c) The angle between track and wind direction.  
d) It is not shown at all.

How many elements of the vector triangle are needed in order that the triangle may be solved?

a) 3  
b) 4  
c) half  
d) 6

What is the best defence against enemy detection of active navigation systems, but another approach is to use only ‘passive’ systems. Passive systems do not transmit, merely receiving signals such as those transmitted by GPS satellites and combining that information with up to three inertial navigation systems (GPS + triple INS).

Conclusion

Despite the availability of very accurate navigation systems, a great deal of aviation training time is devoted to old fashioned methods such as map reading, particularly in a student’s early stages of training.

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Despite the availability of very accurate navigation systems, a great deal of aviation training time is devoted to old fashioned methods such as map reading, particularly in a student’s early stages of training.
The pilot must enter important details on the log card for each leg. He must measure the tracks with a protractor and the distances using dividers.

Temperature is required in order to calculate the true airspeed (TAS) from the calibrated airspeed (CAS).

**Fuel Planning**

The time for each leg and the fuel required is also calculated and logged on the card. Running out of fuel in a car is inconvenient, in an aircraft it is disastrous.

The timings on the log cards also help pilots pass accurate estimates of time of arrival (ETA’s) at waypoints or destinations.

**Safety Altitudes**

The safety altitude is calculated by adding 1000 ft to the highest elevations (mountains, TV masts etc) on or near the track, and rounding up to the nearest 100 ft. If meteorological conditions deteriorate, the pilot must always be prepared to climb above the safety altitude.

**Air Traffic Control Flight Plan**

Before a pilot commences his flight he must submit an ATC Flight Plan so that ATC units along his route and at his destination have details of his intended flight.

If you are flying an a/c at 2000' and you fly into cloud, to what altitude must you climb?

a) 2700 ft  
b) 1800 ft  
c) 3800 ft  
d) 2800 ft

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**Radio Aids**

The next time you listen to a small portable radio, try turning the radio through 360° in the horizontal plane. You will find that there are two points in the sky where reception is best. The Radio Direction Finder (DF or radio compass) works on the same principle to find the direction of the aircraft from a beacon. By using lines from two further beacons (preferably at about 60° from each other), a ‘three position line fix’ can be plotted to accurately locate the position of the aircraft.

**VOR/DME and TACAN**

A more modern method of position finding utilizes VOR/DME (civilian) or TACAN (military) beacons. Both give the same information, namely the magnetic bearing from the beacon to the aircraft, and the range.

**Astro Navigation**

Astro navigation works on the principle of using a sextant to measure the angle of the sun or stars to determine position. Perhaps its only advantage nowadays is that it cannot be jammed. It has been superseded by GPS.