THE FLIGHT COMPUTER AND NAVIGATION PLOTTER

GOAL: HOW TO USE A MANUAL E6B FOR FLIGHT PLANNING AND ENROUTE NAVIGATION.

COMPUTING SIDE OF E6B

- **Distance, Speed, and Time Enroute**
- **Fuel Consumption and Duration**
- **Computation of True Airspeed using Temperature and Altitude**
- **Determination of Density Altitude**
- **True Altitude Calculation & Interpellation techniques for interpreting temp/alt data**

WIND SIDE OF E6B

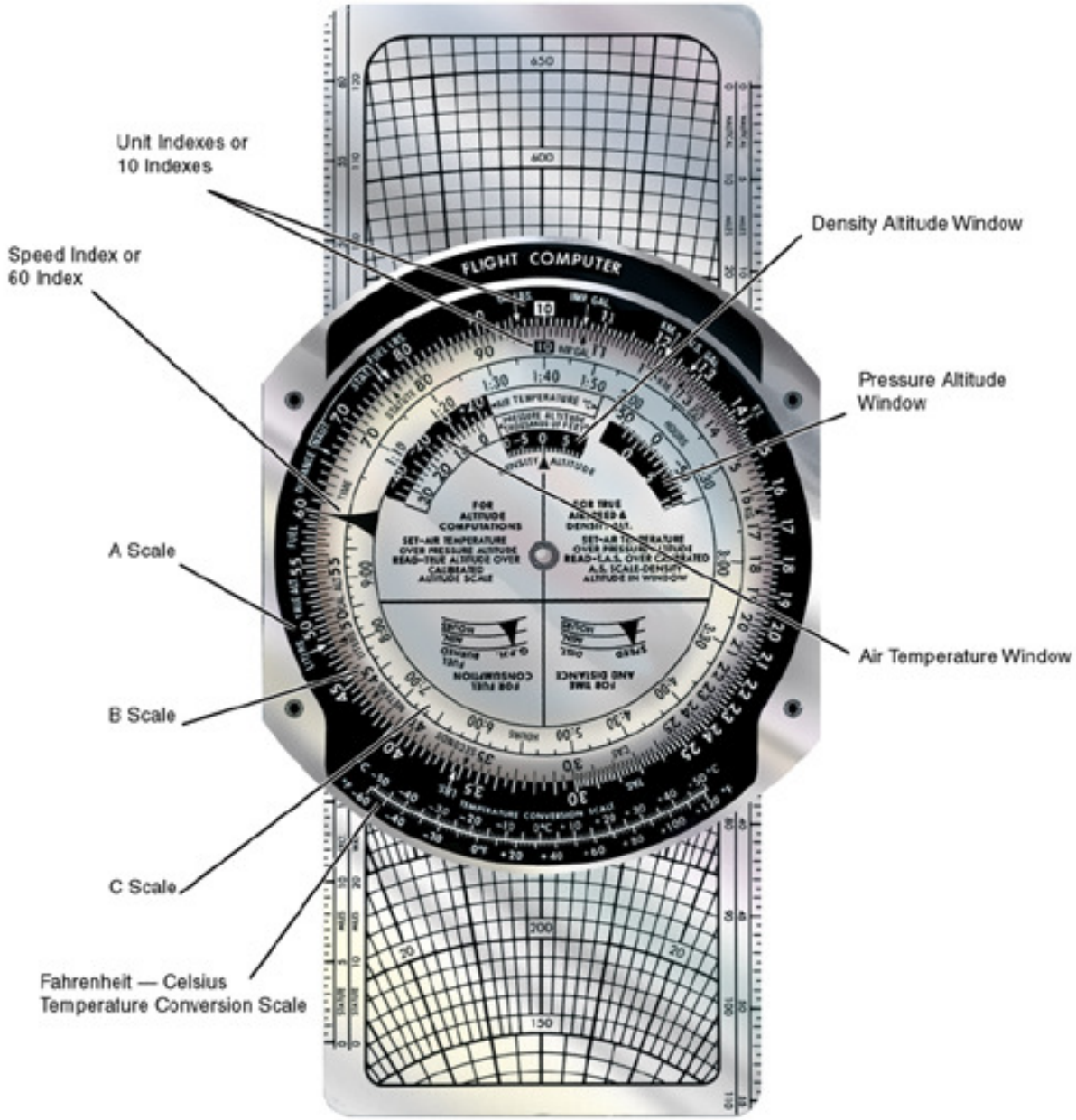
- **Determination of Wind Correction Angle, and True Heading**
- **Determination of Ground Speed, Variation and Magnetic Heading**
- **Use of Deviation to determine Compass Heading**

NAVIGATION PLOTTER

- **Plotting and determining**
- **True Course**
- **Distances**

MANY EXERCISES ALONG THE WAY…..

THE FLIGHT COMPUTER



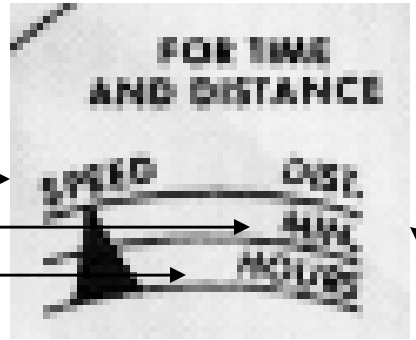
THE FLIGHT COMPUTER

SPEED, DISTANCE, TIME, FUEL

<u>No complex formulas –LEGENDS ON E6B</u>

<u>Speed, Distance</u> A

<u>Time</u> B, C



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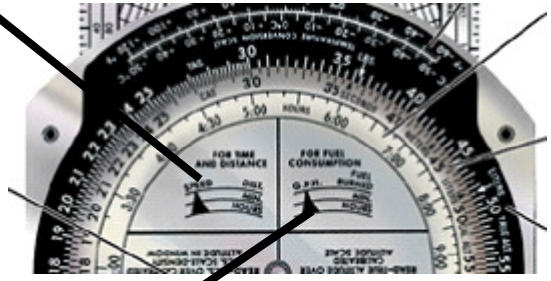
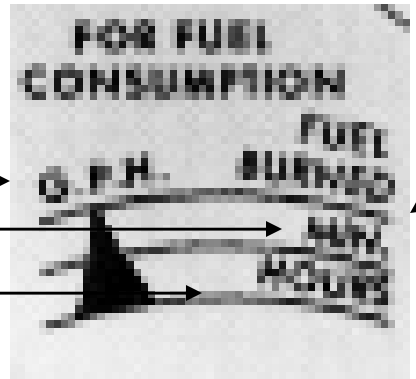


<u>Gallon per hour, Fuel Burned</u> A

<u>Time</u> B, C

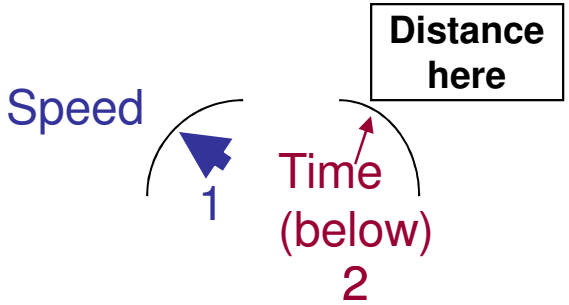


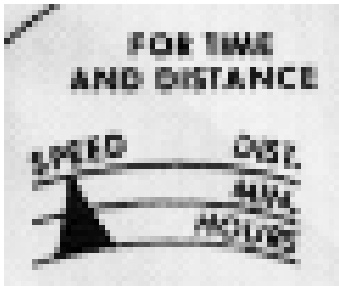
THIS WILL BECOME LESS COMPLEX AS WE DO PRACTICE EXERCISE

THE FLIGHT COMPUTER
DISTANCE

DISTANCE (Scale A, above the time) =

1. **Speed (Scale A-speed index) ***
2. **Time (Scale B)**





Use either Minutes (B) or Hours (C)

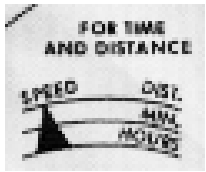
SPEED 120

TIME 120 MINUTES

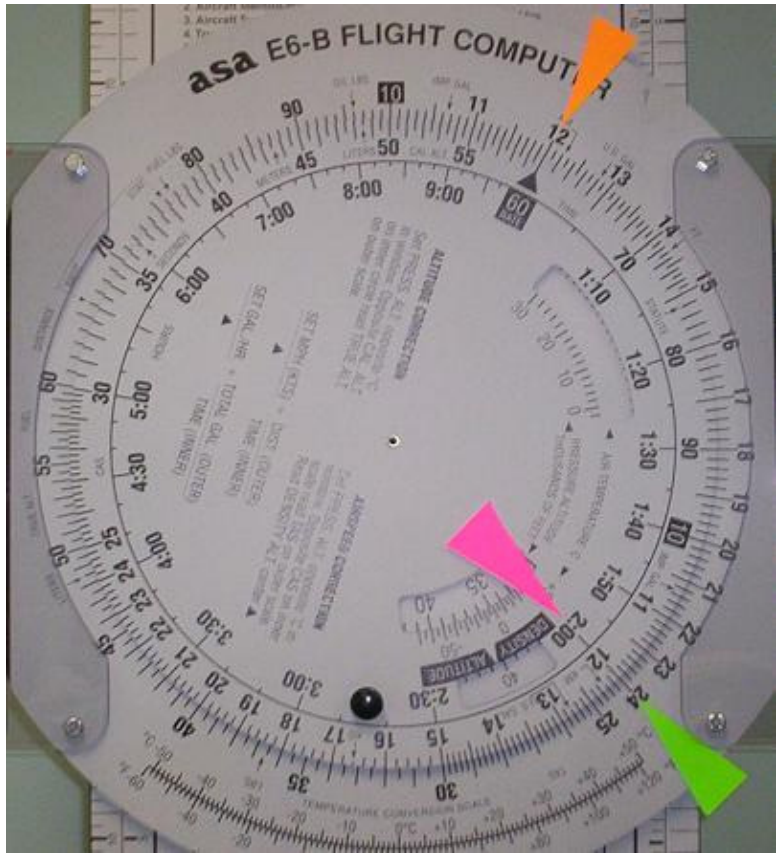
DISTANCE = 240 MILES

CAUTION: SCALABILITY (12 can be 12, 120, 1200)
APPLY COMMON SENSE

THE FLIGHT COMPUTER
DISTANCE PRACTICE



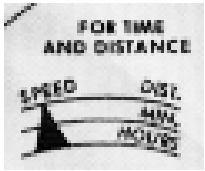
Problem	1. Speed	2. Time	Distance
1	120 (A)	120 minutes (B)	240



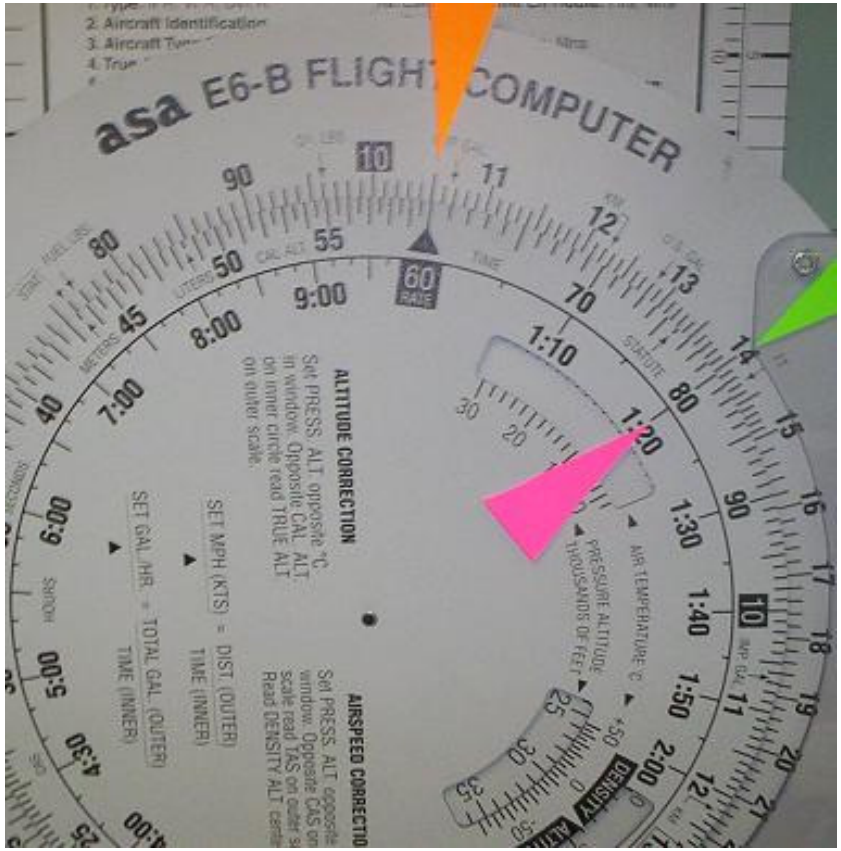
SM or NM: What & Where
HOW TO CONVERT
#1 240 SM = 208 NM

*ALWAYS use KTS not MPH, and NM not SM

THE FLIGHT COMPUTER
DISTANCE PRACTICE

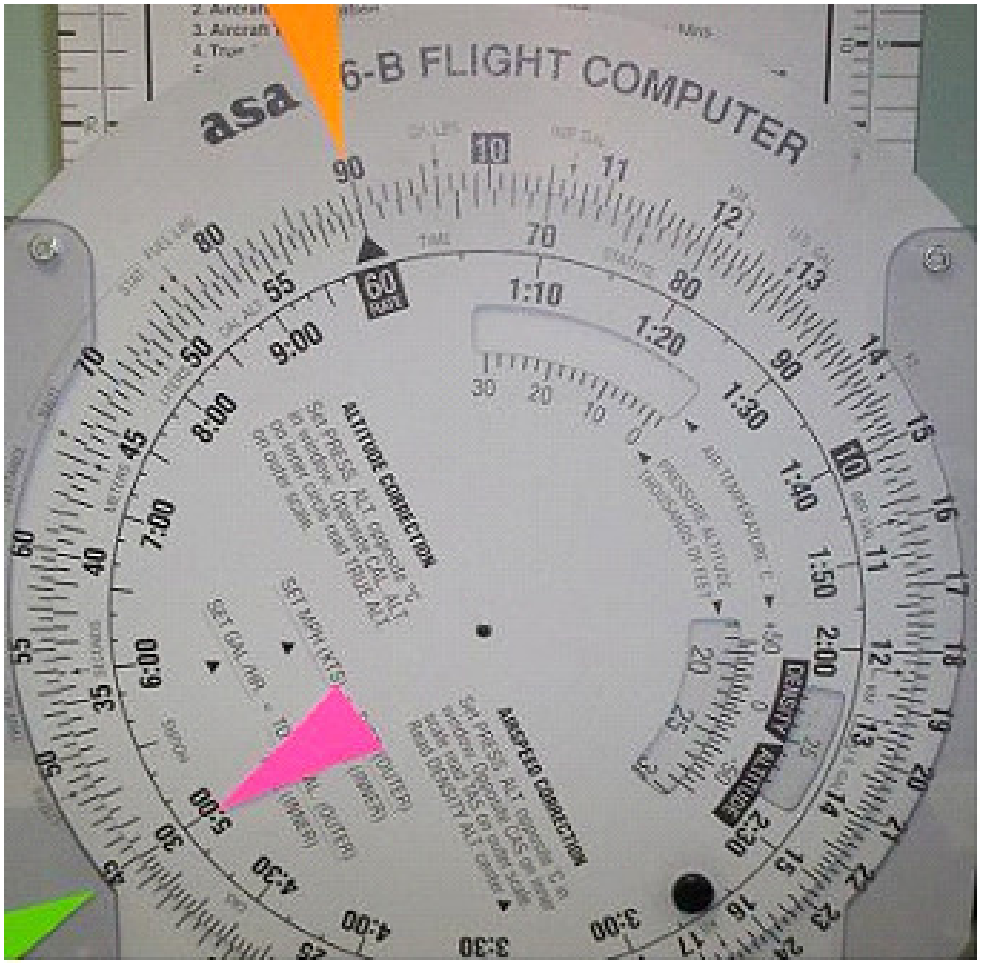


Problem	1. Speed	2. Time	Distance
2	105 MPH	1 HR 20 Minutes	140 SM



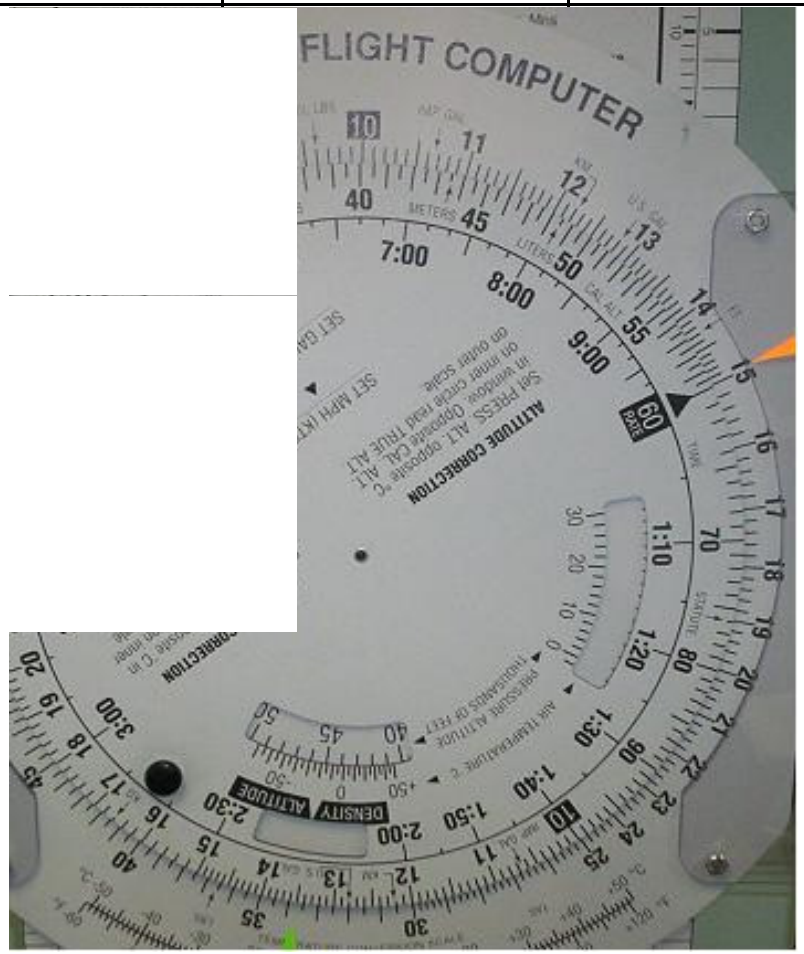
THE FLIGHT COMPUTER
DISTANCE PRACTICE

Problem	1. Speed	2. Time	Distance
3	90 MPH	300 Minutes	450



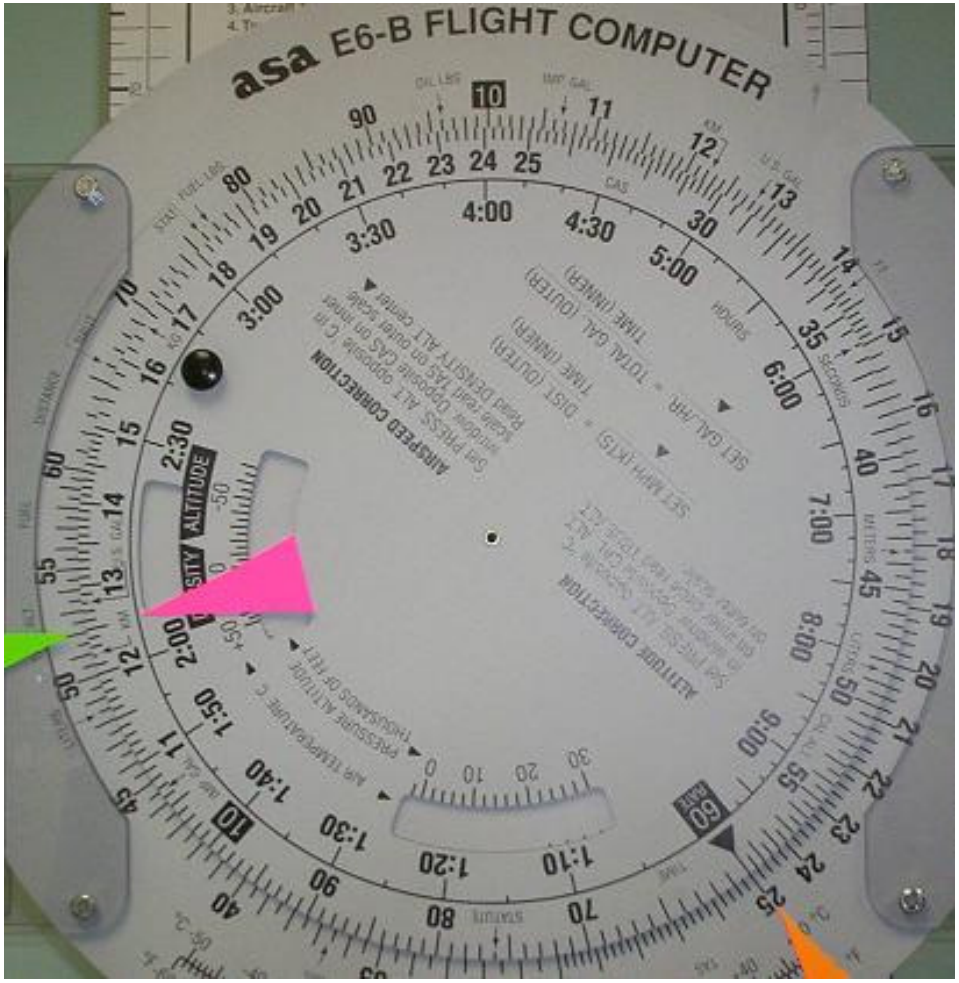
THE FLIGHT COMPUTER
DISTANCE PRACTICE

Problem	1. Speed	2. Time	Distance
4	150 MPH	2 HRS 15 MIN	338



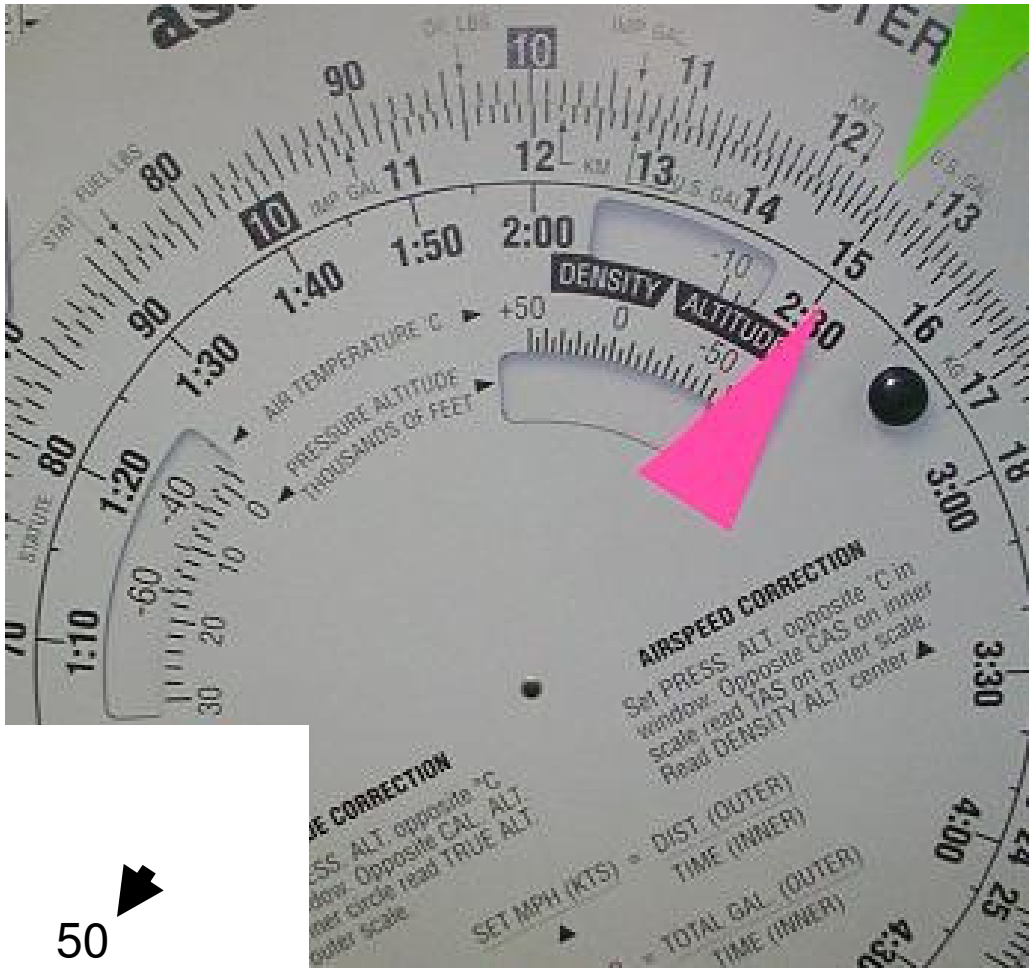
THE FLIGHT COMPUTER
DISTANCE PRACTICE

Problem	1. Speed	2. Time	Distance
5	250 MPH	2 HRS 05 MIN	521



THE FLIGHT COMPUTER
DISTANCE PRACTICE

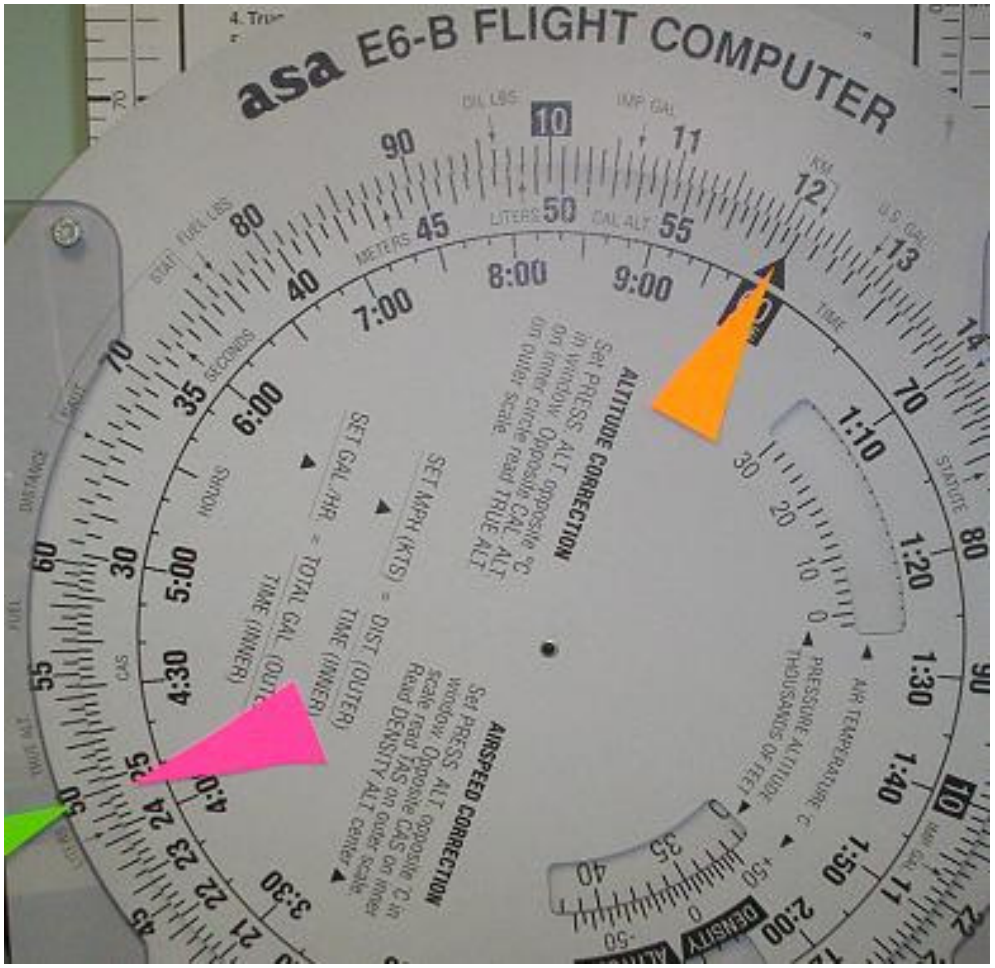
Problem	1. Speed	2. Time	Distance
6	500 MPH	15 MIN	125



50

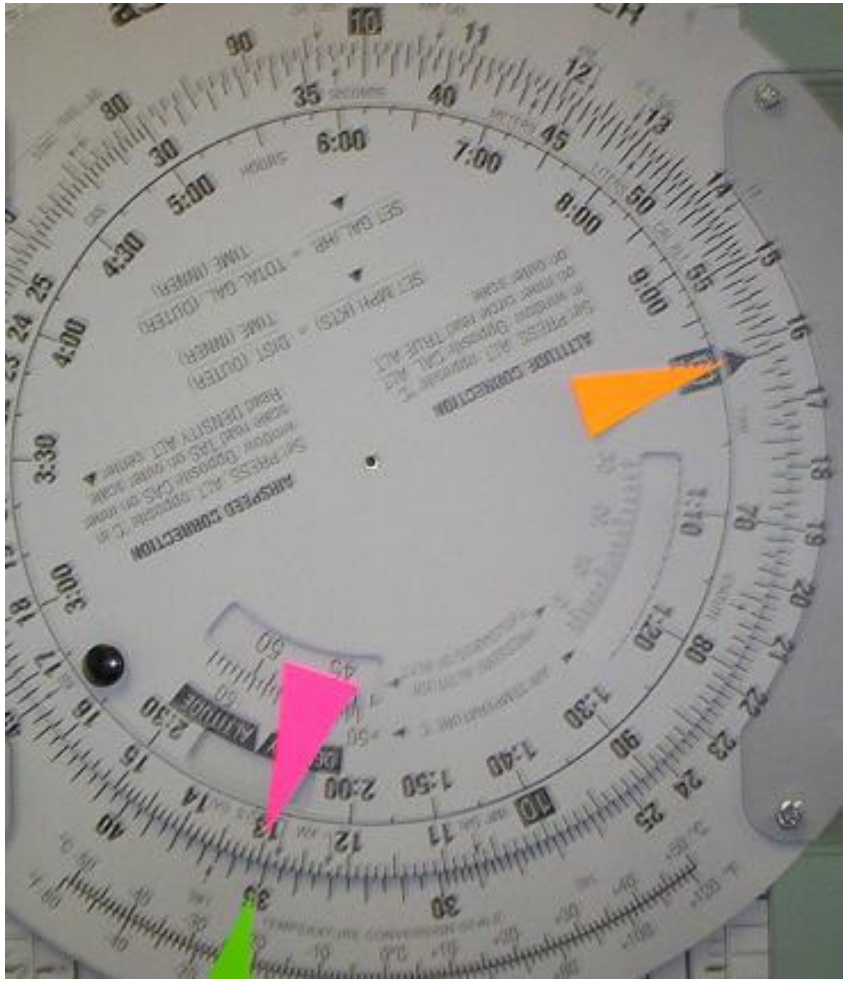
THE FLIGHT COMPUTER
DISTANCE PRACTICE

Problem	1. Speed	2. Time	Distance
7	123 MPH	4 HRS 04 MIN	500



THE FLIGHT COMPUTER
DISTANCE PRACTICE

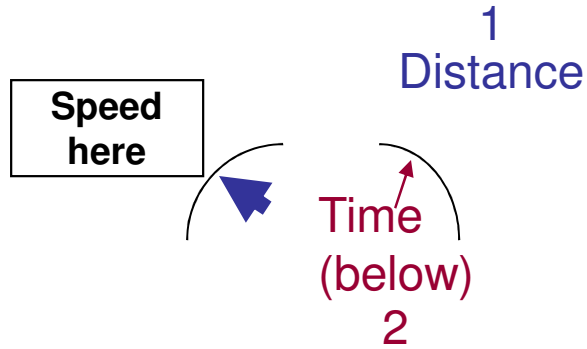
Problem	1. Speed	2. Time	Distance
8	163 MPH	13 MIN	35

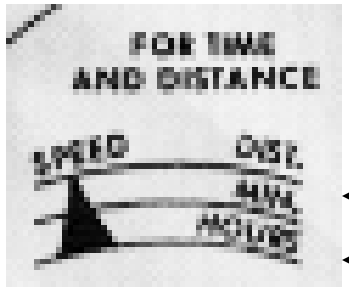


THE FLIGHT COMPUTER
SPEED

SPEED (Scale A, above the speed index) =

1. **Distance (Scale A-put over time) ***
2. **Time (Scale B)**





Use either
Minutes (B) or
Hours (C)

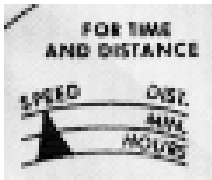
DISTANCE 240

TIME 120 MINUTES

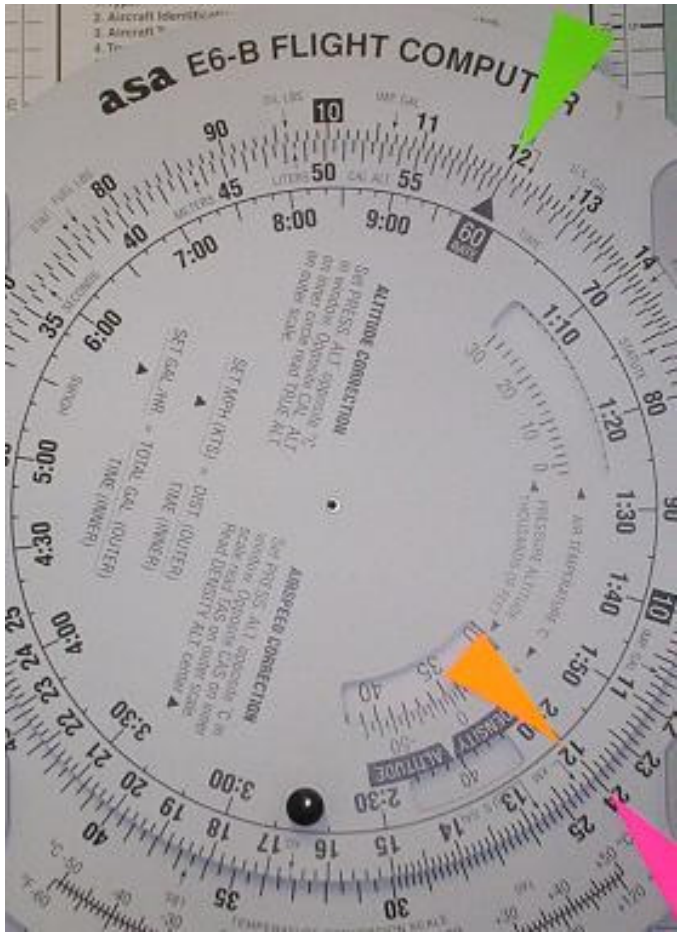
SPEED = 120 MILES

<u>where time is 10 minutes or greater</u>

THE FLIGHT COMPUTER
SPEED

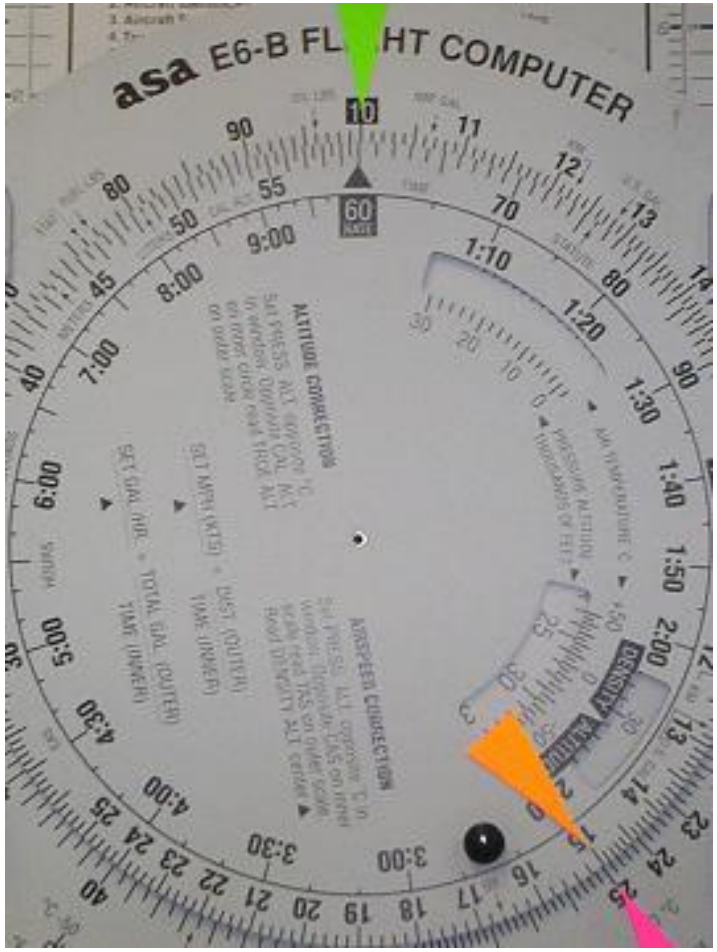


Problem	Distance	Time	SPEED
9	240 SM (A)	2 HRS 00 MINS (B=120 & C)	120



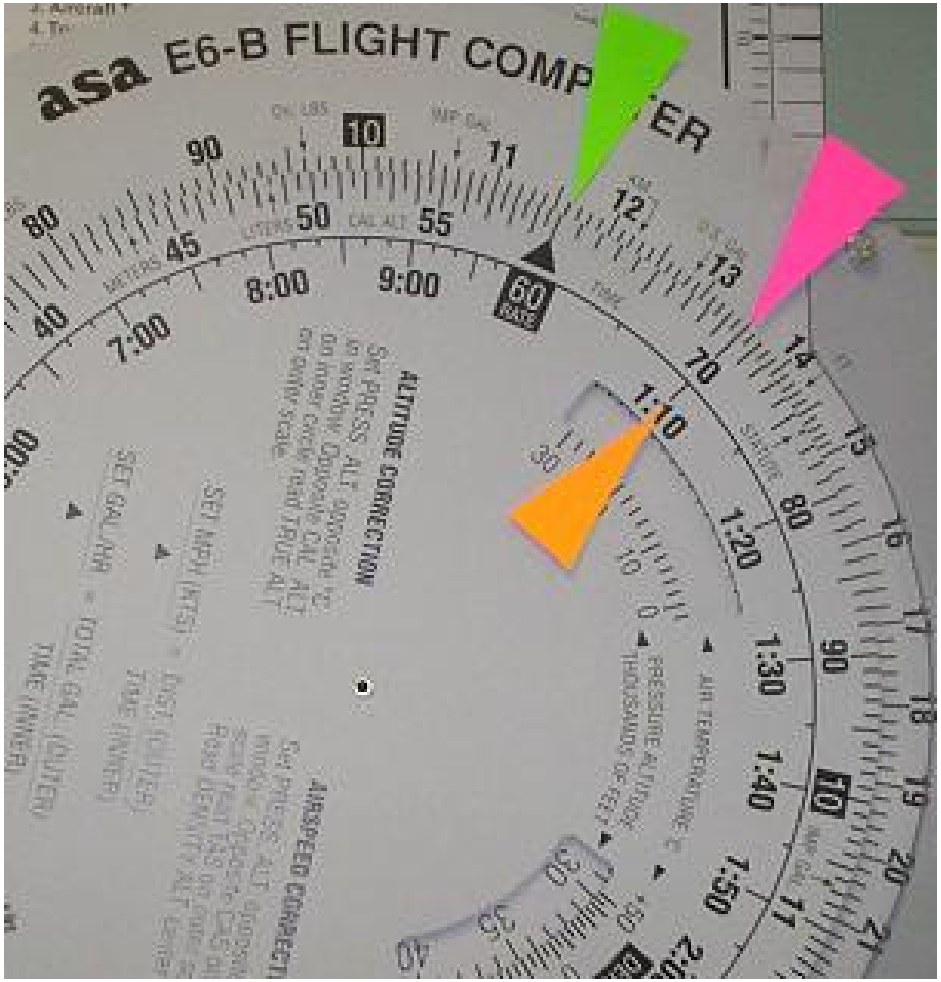
THE FLIGHT COMPUTER
SPEED

Problem	Distance	Time	SPEED
10	25 SM	15 MIN	100



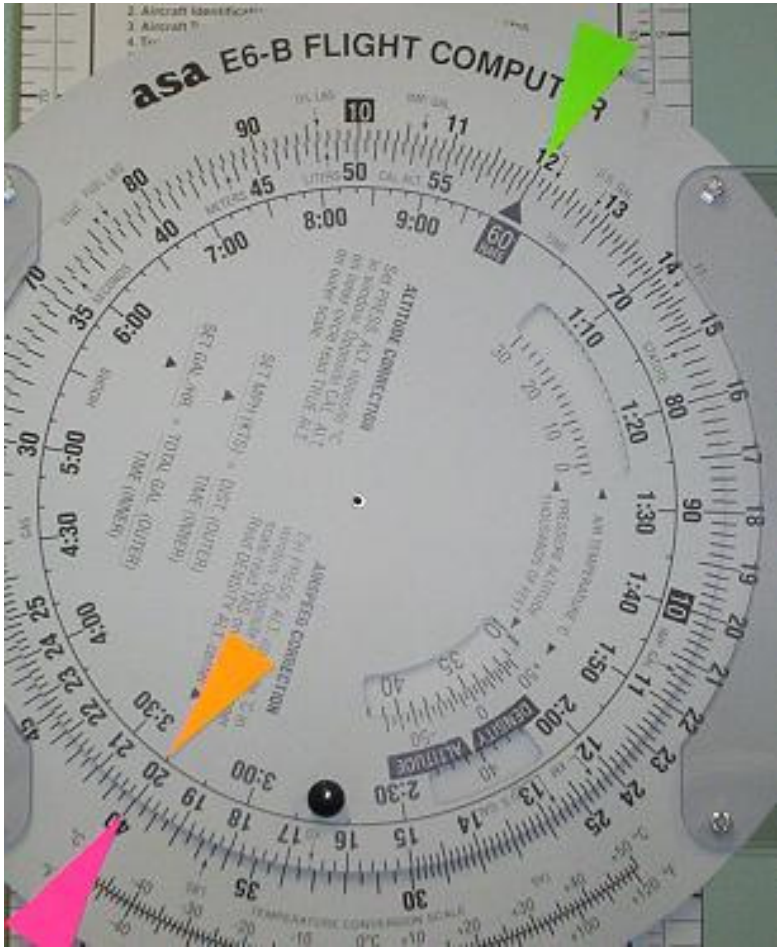
THE FLIGHT COMPUTER
SPEED

Problem	Distance	Time	SPEED
11	135 SM	1 HR 10 MIN	116



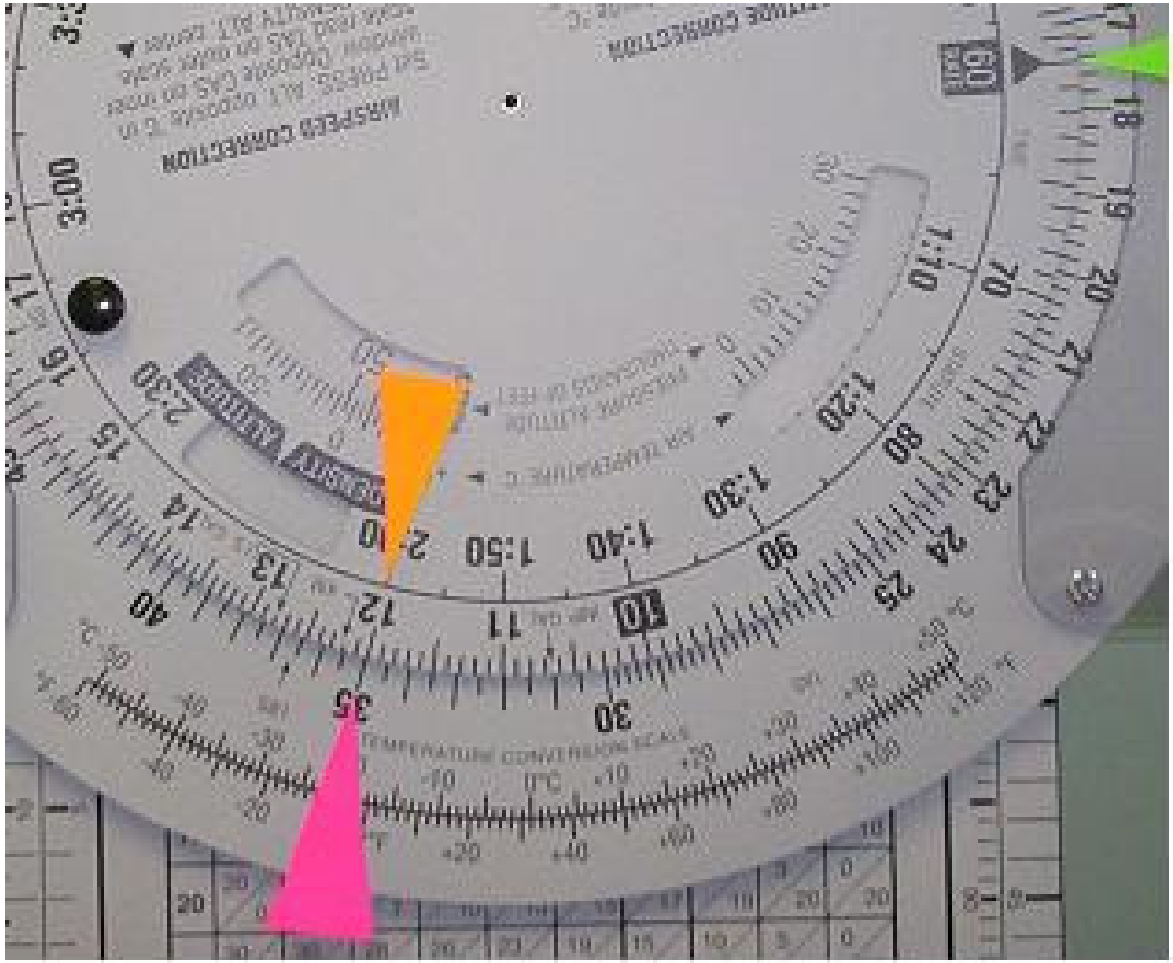
THE FLIGHT COMPUTER
SPEED

Problem	Distance	Time	SPEED
12	400 SM	3 HR 20 MIN	120



THE FLIGHT COMPUTER
SPEED

Problem	Distance	Time	SPEED
13	35 SM	12 MIN	175



THE FLIGHT COMPUTER
SPEED

Problem	Distance	Time	SPEED
14	75 SM	1 HR 30 MIN	50

THE FLIGHT COMPUTER
SPEED

Problem	Distance	Time	SPEED
15	15 SM	12 MIN	75

THE FLIGHT COMPUTER
SPEED

Problem	Distance	Time	SPEED
16	375 SM	3 HR 00 MIN	125

THE FLIGHT COMPUTER

SPEED

Speed (A-speed index) = Distance (A) / Time (B) (underneath the distance) <u>where time is <10 minutes</u>

We treat the B scale as seconds and the C scale as Minutes. Instead of using the "Speed Index" we use a special point on the B scale found at **36** (SEC.)

Example: Fly 1 mile in 45 seconds. Set <u>1</u> (A scale) over <u>45</u> (B scale) and locate the SEC points (36 on B scale). Groundspeed above is 80 on the A scale.

Practice

17. 1 mile in 120 seconds (or 2:00 Minutes) = 30
18. 5 miles in 45 seconds = 400
19. 3 miles in 2 minutes 30 seconds = 72
20. 1 mile in 8 seconds = 450
21. 7.5 miles in 4 minutes and 30 seconds = 100

Quick mental math on Airspeed
Are we there yet? How long?

If the groundspeed is 150 knots, multiply the distance by four and **drop the last zero**: 20 miles*4 = 80. It will take **eight** minutes at 150.

For 60, multiply the miles by 1 since your are traveling at 1 mile per minute.

For 90, divide miles by 1.5 since you are going 1.5 miles each minute.

For 100, multiply by six for 120, minus the zero for 12 minutes.

For 120, divide by two since you are traveling at 2 miles per minute.

For 150, divide by 2.5 since you are traveling at 2.5 miles per minute.

For 180, just divide by three since you are traveling at 3 miles per minute.

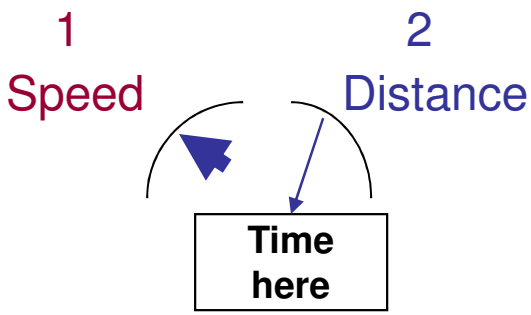
Etc, etc, etc.

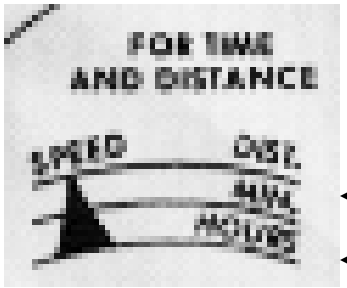
THE FLIGHT COMPUTER
TIME

TIME (Scale B or C, below Distance) =

1. Speed (Scale A)

2. Distance (Scale A)





Use either
Minutes (B) or
Hours (C)

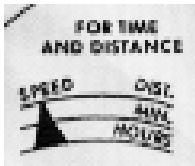
SPEED 120

DISTANCE = 240

TIME = 120 MIN or 2:00 HRS

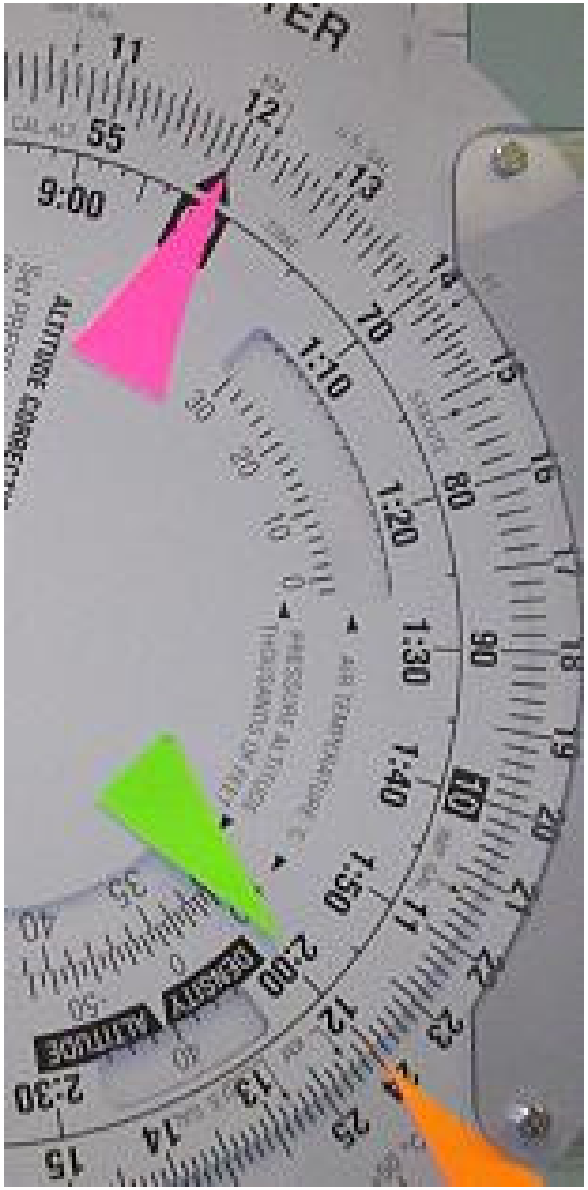
THE FLIGHT COMPUTER

TIME



Time (B-minutes/C-hours & minutes)
= Distance (A) / Speed (A-index)

Problem	SPEED	Distance	TIME
22	120	240	2 HR 00 MIN



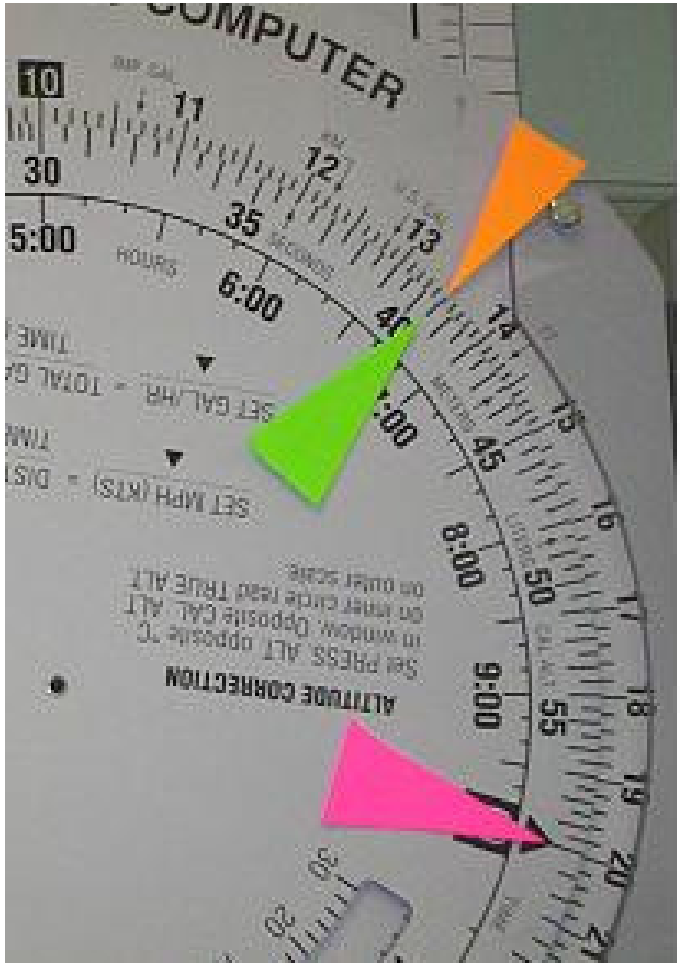
THE FLIGHT COMPUTER

TIME

Problem	SPEED	Distance	TIME
23	105	25	14:17

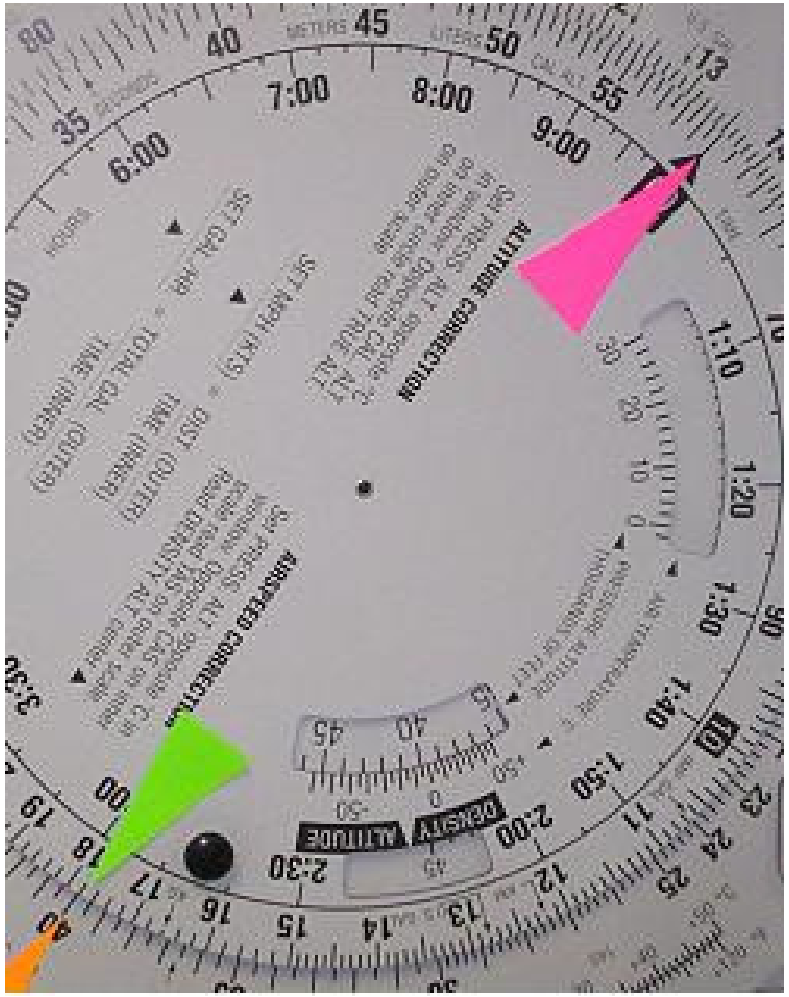
THE FLIGHT COMPUTER
TIME

Problem	SPEED	Distance	TIME
24	200	135	40:30’



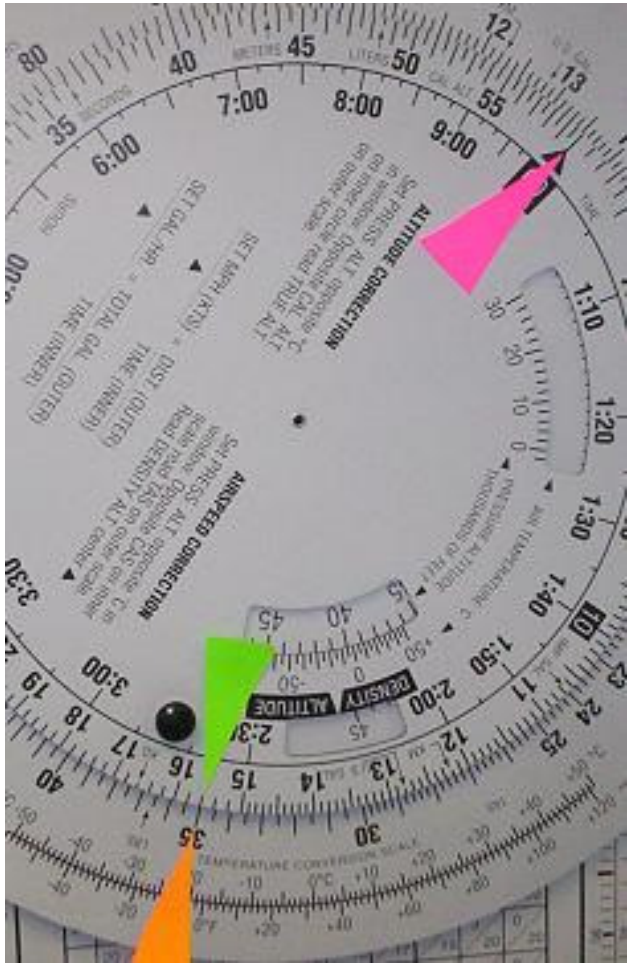
THE FLIGHT COMPUTER
TIME

Problem	SPEED	Distance	TIME
24	135	400	2:57:47’



THE FLIGHT COMPUTER
TIME

Problem	SPEED	Distance	TIME
25	135	35	15:33

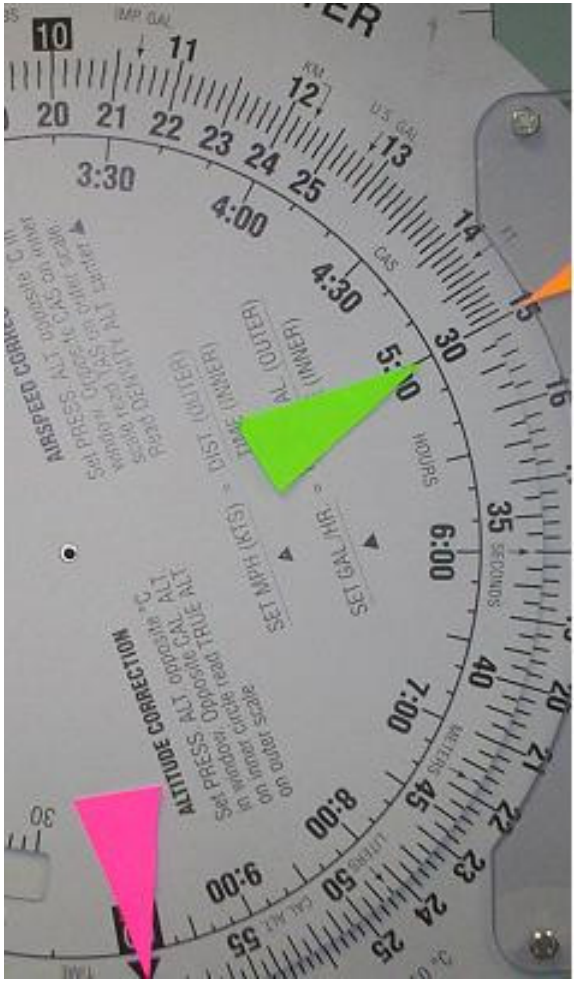


THE FLIGHT COMPUTER
TIME

Problem	SPEED	Distance	TIME
26	90	75	50:00

THE FLIGHT COMPUTER
TIME

Problem	SPEED	Distance	TIME
27	300	15	03:00



THE FLIGHT COMPUTER

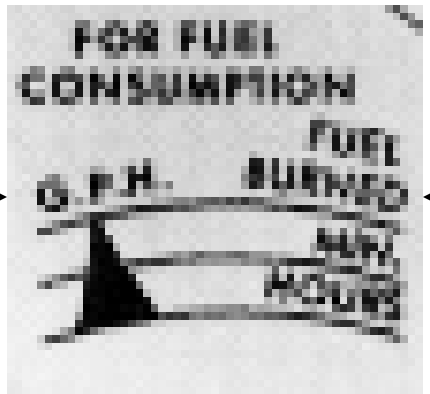
TIME

Problem	SPEED	Distance	TIME
28	90	375	4:10:00

THE FLIGHT COMPUTER
FUEL CONSUMPTION AND RATE

RATE OF CONSUMPTION →

(WORK LIKE SPEED)



← **TOTAL GALLONS**

(WORK LIKE DISTANCE)

G.P.H. 5

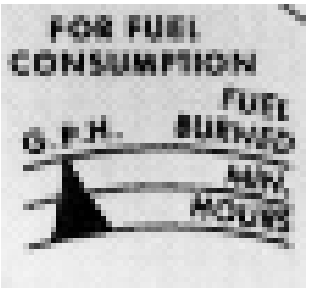
TIME 120 MINUTES

FUEL BURNED = 10 GALLONS

FUEL BURNED 10

TIME 120 MINUTES

RATE = 5 G.P.H.



THE FLIGHT COMPUTER
FUEL

Problem	1. GPH	2. TIME	**FUEL CONSUMPTION**
29	5 (A)	120 minutes (B)	(A)= 10 GALLONS

THE FLIGHT COMPUTER
FUEL

Problem	1. GPH	2. TIME	**FUEL CONSUMPTION**
30	8.5 GPH	1 HR 20 Minutes	11.3 G

THE FLIGHT COMPUTER
FUEL

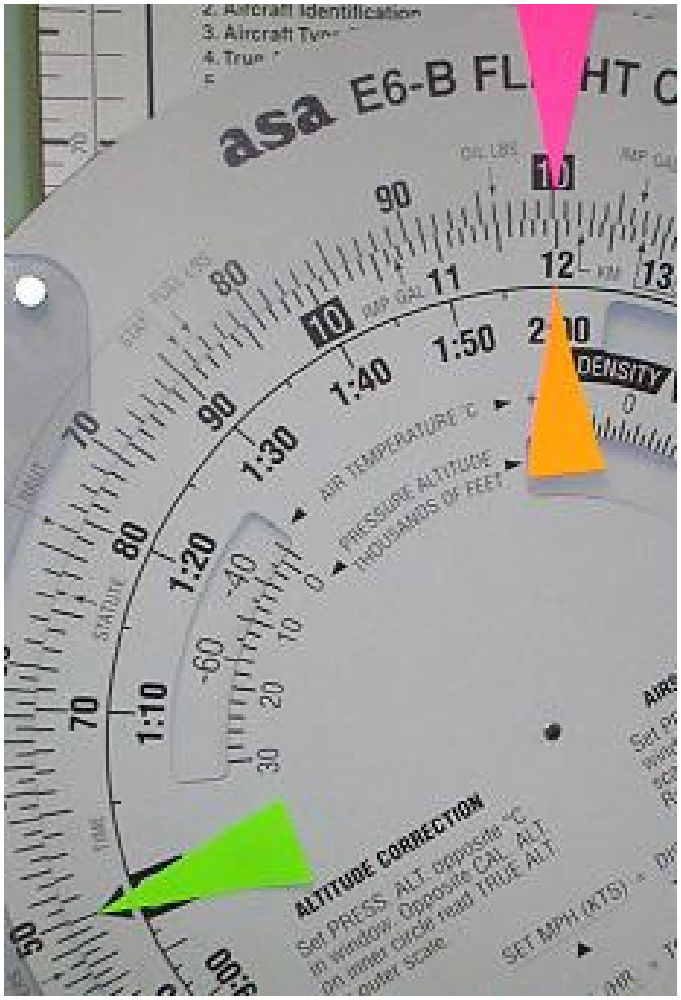
Problem	1. GPH	2. TIME	**FUEL CONSUMPTION**
31	90 GPH	300 Minutes	450.0 G

THE FLIGHT COMPUTER
FUEL

Problem	1. GPH	2. TIME	**FUEL CONSUMPTION**
32	13.5 GPH	2 HRS 15 MIN	30.4 G

THE FLIGHT COMPUTER
FUEL CONSUMPTION RATE

Problem	1. GALLONS	2. TIME	RATE OF CONSUMPTION
33	10 (A) G	120 minutes (B)	(A)= 5 GPH



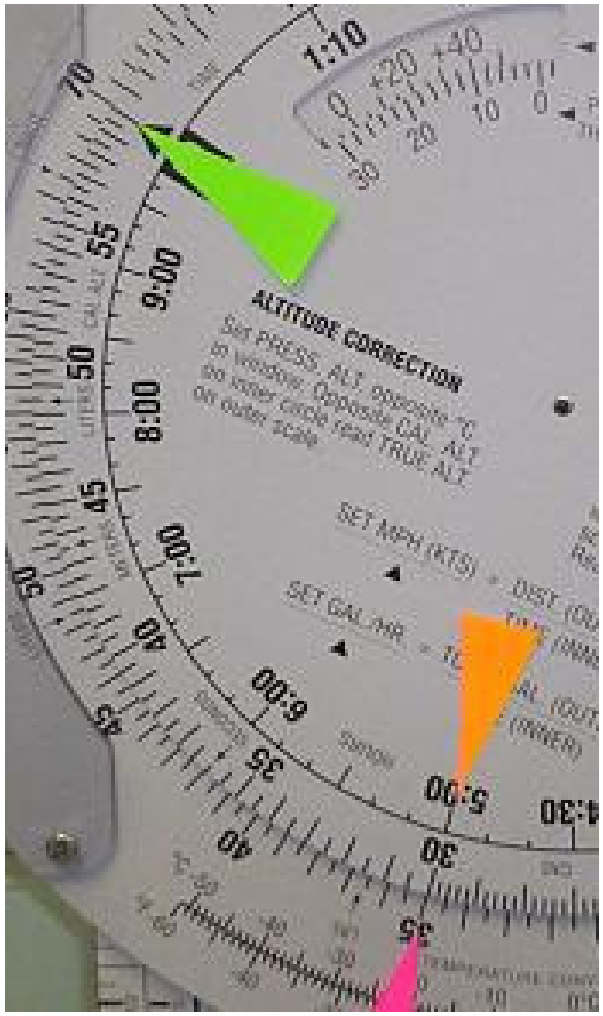
THE FLIGHT COMPUTER
FUEL

Problem	1. GALLONS	2. TIME	**RATE OF CONSUMPTION**
34	12 G	1 HR 20 Minutes	9 GPH

THE FLIGHT COMPUTER

FUEL

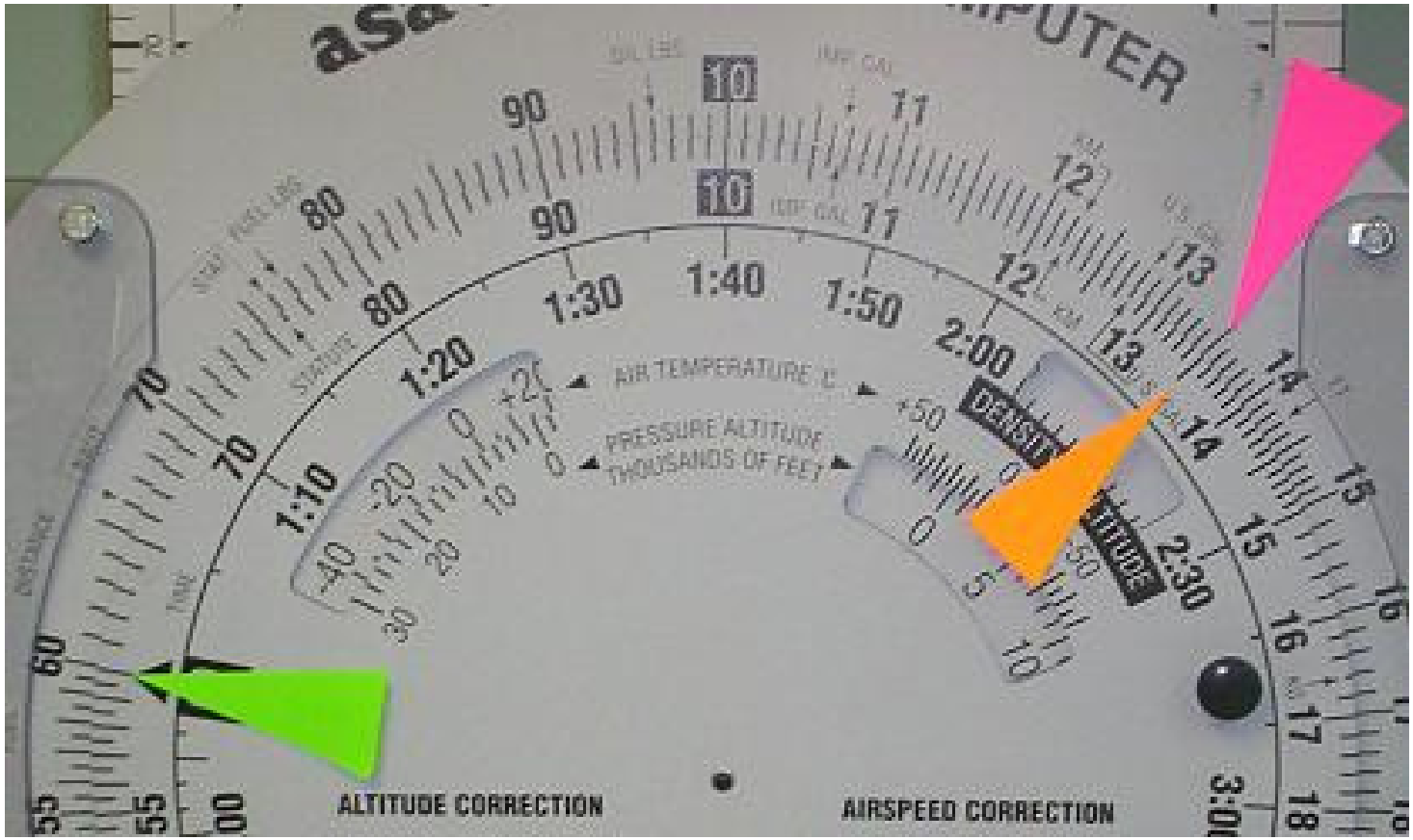
Problem	1. GALLONS	2. TIME	**RATE OF CONSUMPTION**
35	35 G	300 Minutes	7 GPH



THE FLIGHT COMPUTER

FUEL

Problem	1. GALLONS	2. TIME	**RATE OF CONSUMPTION**
36	13.5 G	2 HRS 15 MIN	6 GPH



THE FLIGHT COMPUTER
AIRSPEED

WHAT YOU SEE (INDICATED AIRSPEED) IS NOT EXACTLY TRUE

V speeds	**KCAS (Knots Calibrated AS)**	**KIAS (Knots Indicated AS)**
V NE	**158**	160
V NO	**126**	128
V A 2300 lbs 1950 1600	**96** **88** **80**	97 89 80
V FE	**86**	85

TRUE AIRSPEED (TAS) - Calibrated airspeed *must be corrected for **altitude** and the **outside air temperature***. (temperature & pressure impact airspeed indicator)

TAS IS HOW FAST YOU ARE MOVING THRU THE AIR NOT HOW FAST YOU ARE MOVING OVER THE GROUND (need wind info for GS)

THE FLIGHT COMPUTER
TRUE AIRSPEED (TAS)

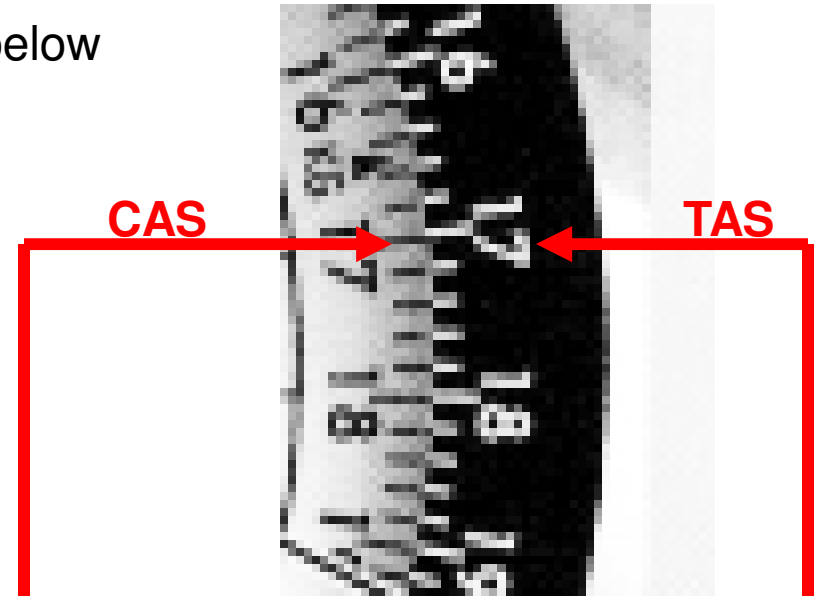
POSITION THE TEMPERATURE OVER THE ALTITUDE

PRESSURE WINDOW

Temperature Celsius Above

Density Altitude

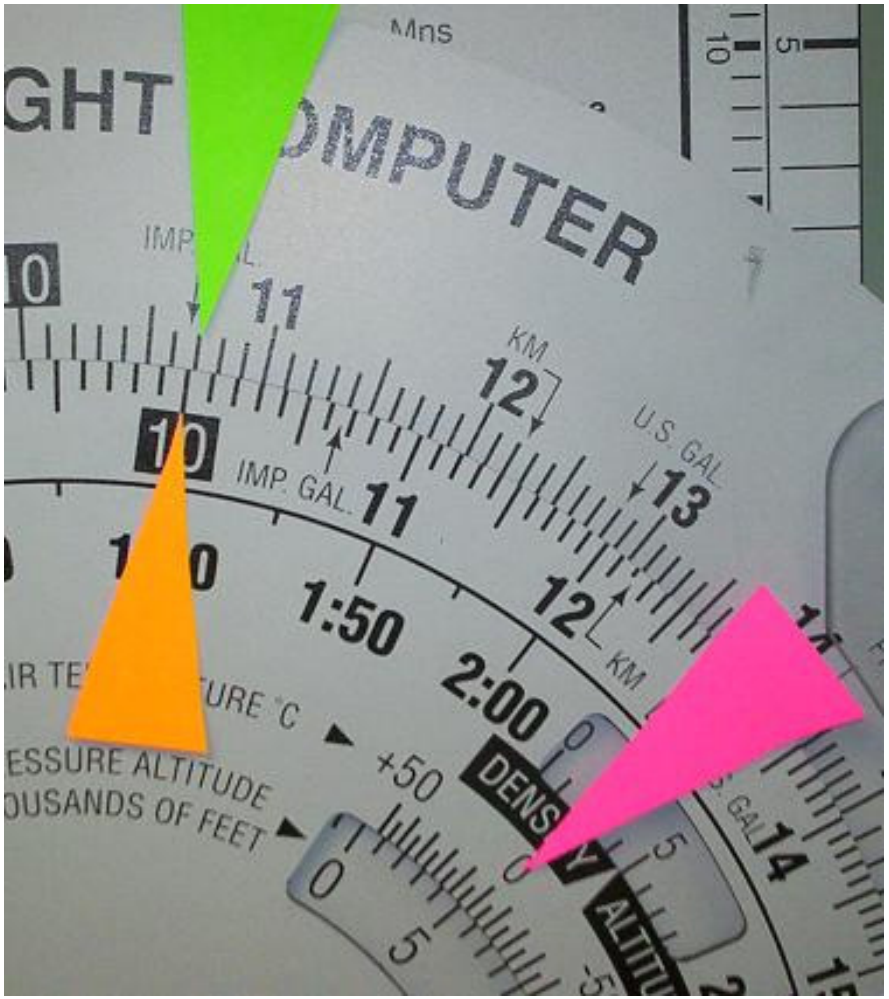
Altitude below



FIND CALIBRATED AIRSPEED ON “B”, THE **TAS IS JUST ABOVE**

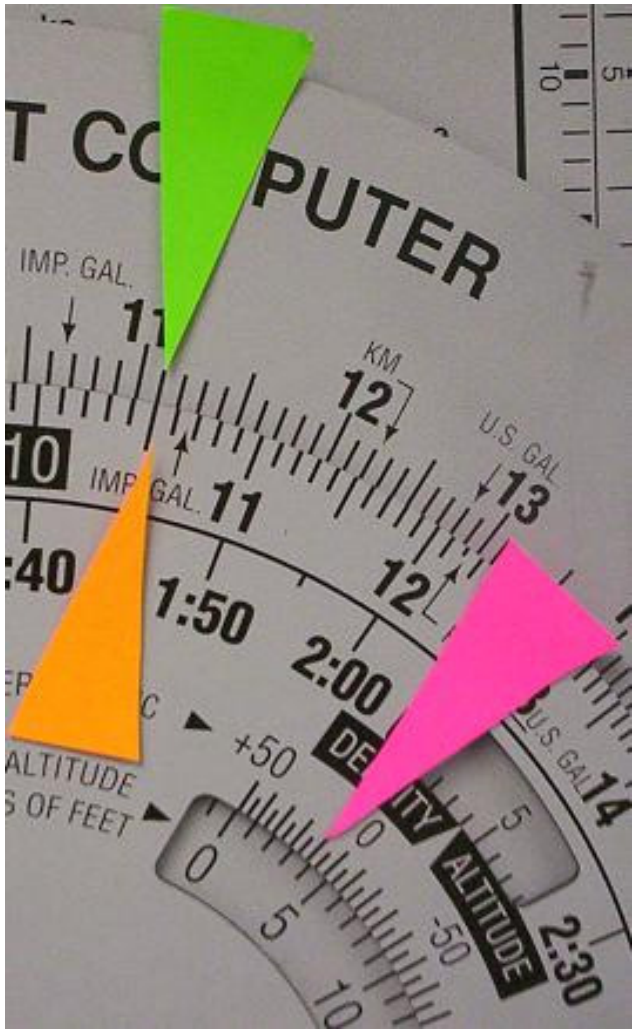
THE FLIGHT COMPUTER
TRUE AIRSPEED (TAS)

Problem	ALT	TEMP C	CAS	TAS	Density Alt.
37	5,000	0	100	107	4389



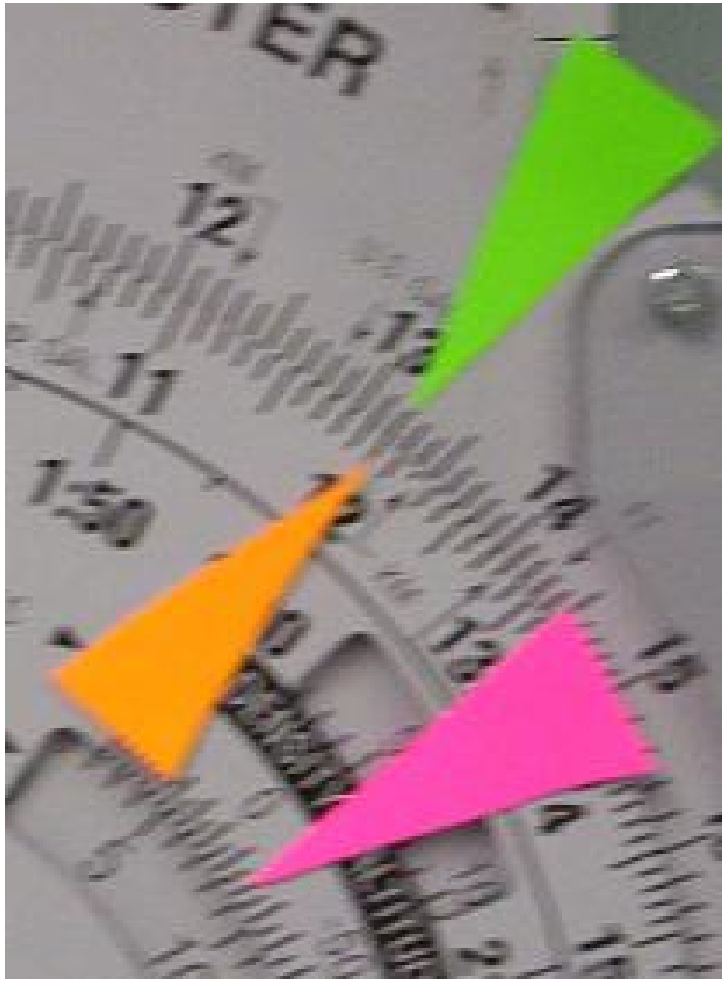
THE FLIGHT COMPUTER
TRUE AIRSPEED (TAS)

Problem	ALT	TEMP C	CAS	TAS	Density Alt.
38	3, 500	+10	105	111	3728



THE FLIGHT COMPUTER
TRUE AIRSPEED (TAS)

Problem	ALT	TEMP C	CAS	TAS	Density Alt.
39	8, 500	-20	120	132	6253



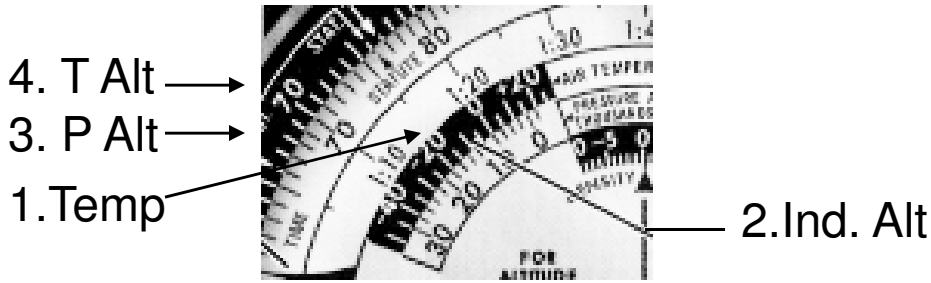
THE FLIGHT COMPUTER

TRUE AIRSPEED (TAS)

Problem	ALT	TEMP C	CAS	TAS	Density Alt.
40	12,000	-30	250	285	9350

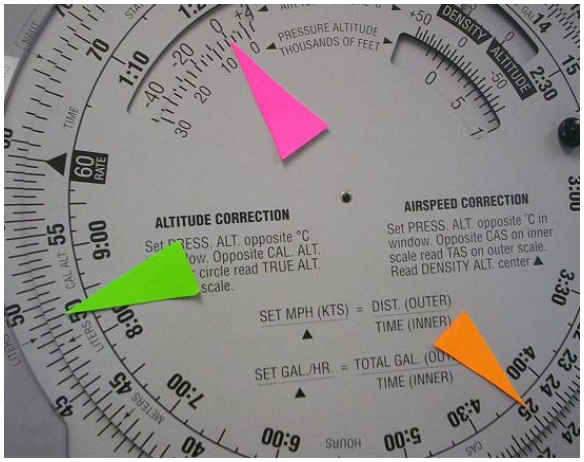
THE FLIGHT COMPUTER
TRUE ALTITUDE

TRUE ALTITUDE : Indicated altitude corrected for temperature & altitude.



1. Adjust wheel so that “indicated altitude” is under the outside air temperature (C)
2. Find “pressure altitude” on the B scale and read the TRUE ALTITUDE above on the A scale. [GET PRESSURE ALTITUDE BY ADJUSTING THE KOLLSMAN WINDOW TO READ 29.92]

Problem	P Alt	TEMP C	TRUE ALTITUDE
41	5,000	0	4900

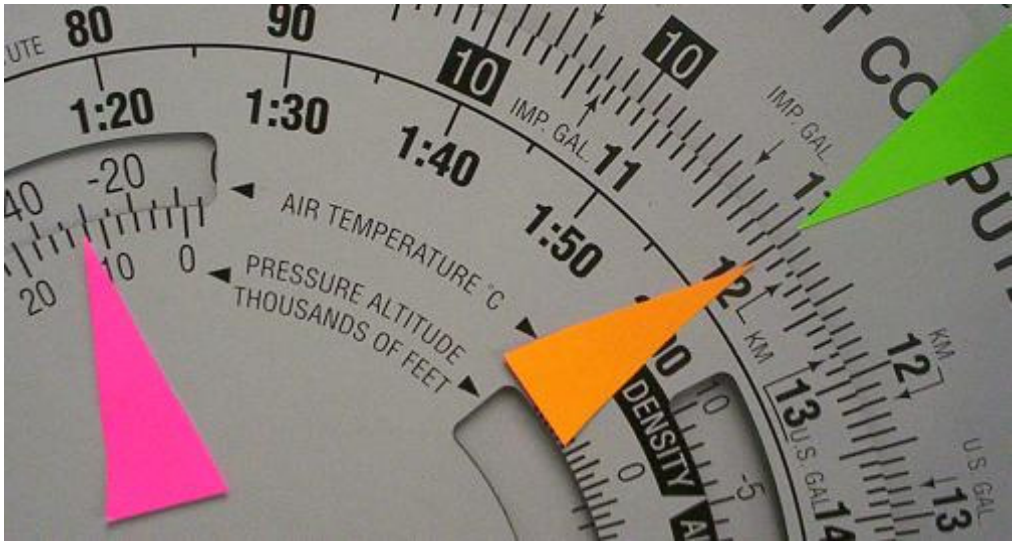


THE FLIGHT COMPUTER
TRUE ALTITUDE

Problem	P Alt	TEMP C	TRUE ALTITUDE
43	8, 500	-20	7930

THE FLIGHT COMPUTER
TRUE ALTITUDE

Problem	P Alt	TEMP C	TRUE ALTITUDE
44	12,000	-30	11037



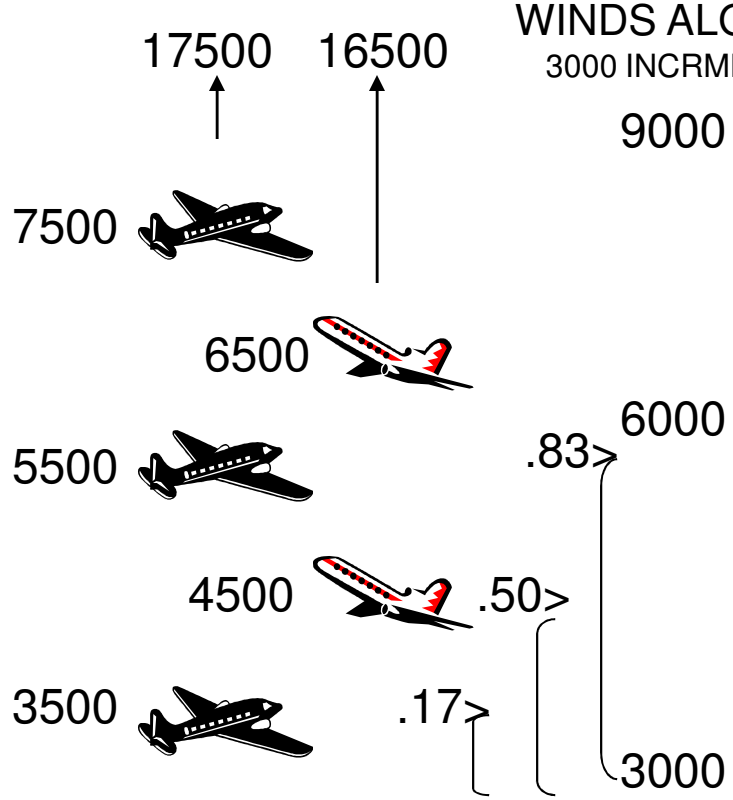
THE FLIGHT COMPUTER
INTERPOLATION FOR WINDS ALOFT

VFR HEADING 0-179→
FLY odd + 500 above 3000 AGL

You tell me WA@ 5500

.83 DIFFERENCE

19740+04



WINDS ALOFT@
3000 INCRMENTS
9000

3000	6000
18015+12	20045+02

INTERPOLATE 4500
.5 difference 3000-6000

Step 1 3000-6000 Difference
Direction 200-180=20
Velocity 45- 15=30
Temperature 12-2=10

Step 2 Cruise Difference
(Example@4500)
Direction .5 x20=10
Velocity .5 x30=15
Temperature .5 x10= 5

Step 3 Add Cruise Difference
Direction 180+10=190
Velocity 15+15= 30
Temperature 12- 5= 7

Wa@4500= **19030+07**

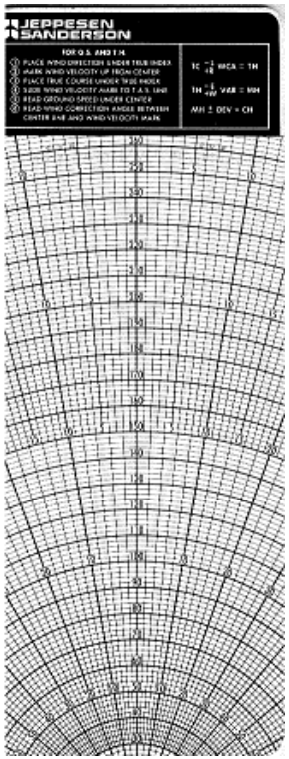
VFR HEADING 180-359←
FLY even **+ 500 above 3000 AGL**

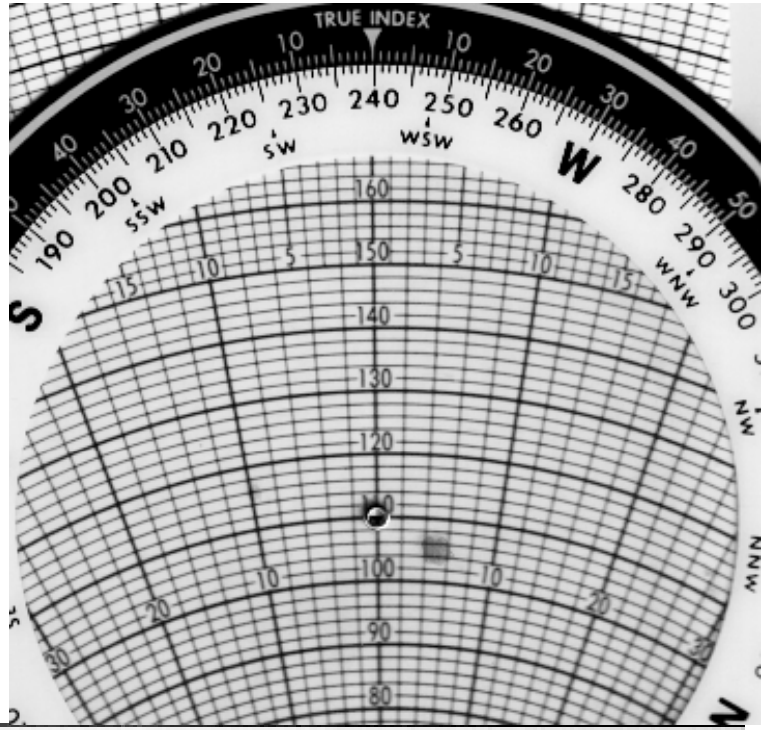
THE FLIGHT COMPUTER
MULTI-PART COMPUTATIONS

HOW MUCH FUEL IS BURNED IN EACH OF THE FOLLOWING?
(Assumption: IAS and CAS are the same for the below problems).
FIND THE TIME AND THEN APPLY TO THE RATE OF FUEL CONSUMED .

WIND = 0, GROUND SPEED = 129 MPH, DISTANCE = 320 SM FUEL CONSUMPTION RATE = 9 GPH (Get Time & Gals)	**TIME 2:29** **22.5 GALS**
ALTITUDE = 7,500, INDICATED AIRSPEED = 105 MPH, TEMPERATURE = + 15C DISTANCE = 256 SM, FUEL CONSUMPTION RATE = 11.5 GPH (Get TAS, Time, Gals)	**TAS 121** **TIME 2:07** **24.4 GALS**
ALTITUDE=7,500, IAS=115, TEMPERATURE=-10C, DISTANCE=335, FUEL CONSUMPTION RATE=8.5 GPH (Get TAS, Time, Gals)	**TAS 127** **TIME 2:38** **22.4 GALS**
GROUNDSPEED=135, WIND=0, TEMPERATURE=-20C, ALTITUDE=9,000, DISTANCE=425, FULE CONSUMPTION RATE = 12 GPH (Get Time and Gals)	**TIME 3:09** **37.8 GALS**

THE FLIGHT COMPUTER
WIND SIDE





FOR G.S. AND T.H.

1. PLACE WIND DIRECTION UNDER TRUE INDEX
2. MARK WIND VELOCITY UP FROM CENTER
3. PLACE TRUE COURSE UNDER TRUE INDEX
4. SLIDE WIND VELOCITY MARK TO T.A.S. LINE
5. READ GROUND SPEED UNDER CENTER
6. READ WIND CORRECTION ANGLE BETWEEN CENTER LINE AND WIND VELOCITY MARK

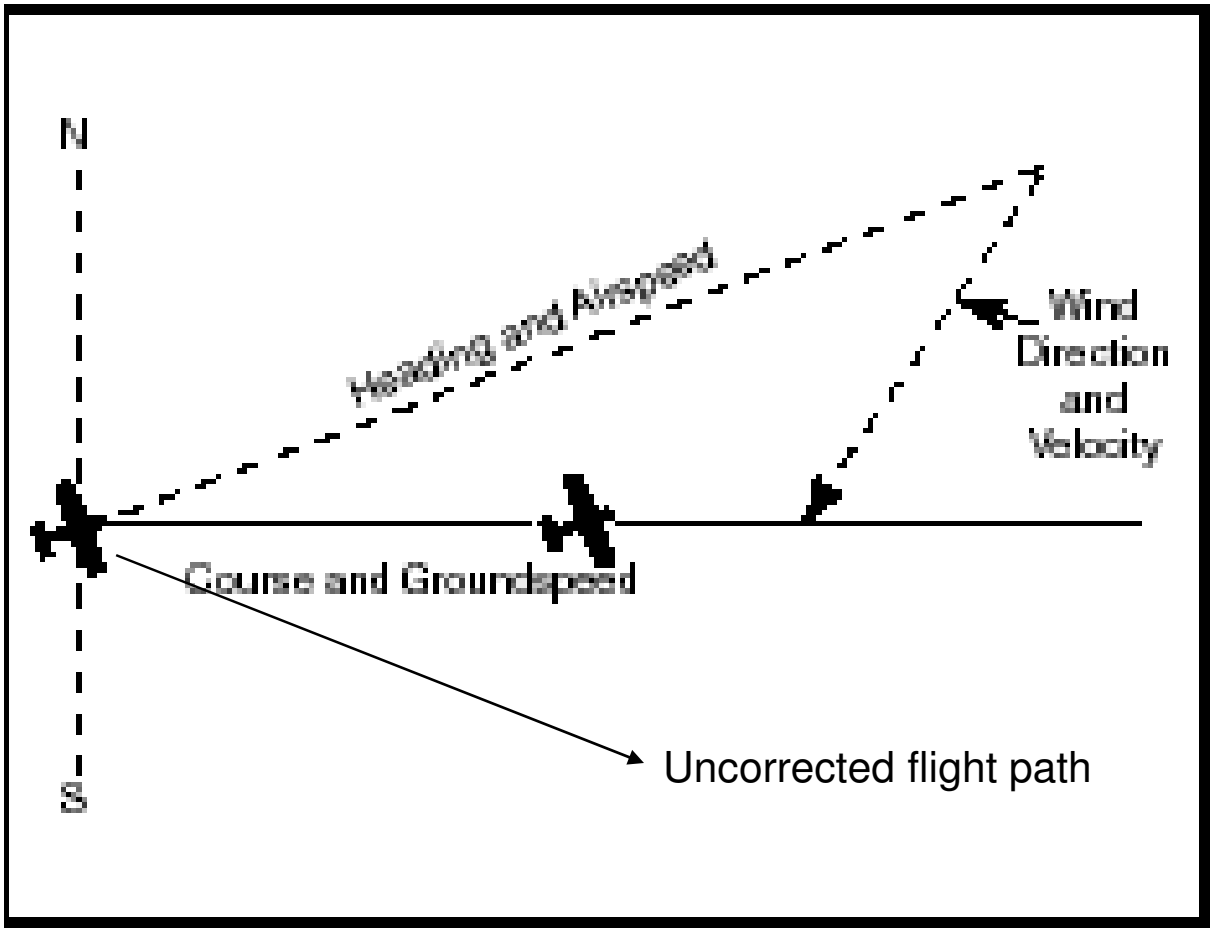
$$TC \begin{matrix} -L \\ +R \end{matrix} WCA = TH$$

$$TH \begin{matrix} -E \\ +W \end{matrix} VAR = MH$$

$$MH \pm DEV = CH$$

THE FLIGHT COMPUTER
WIND SIDE

Use wind side
to determine / GS
resulting from
winds aloft

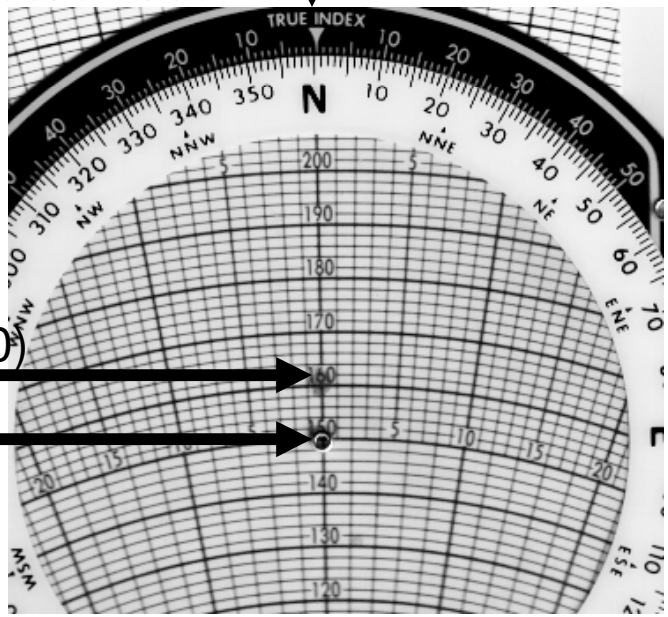


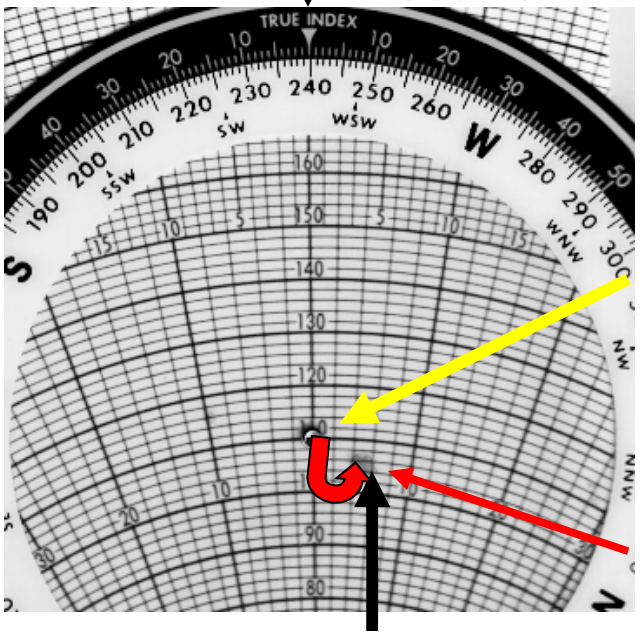
THE FLIGHT COMPUTER
DETERMINING WIND CORRECTION & GROUND SPEED

WIND 360
VELOCITY = 10
TRUE COURSE = 240
TAS = 105

1-Set Wind direction 360

4-Set TC 240





3-Mark above Wind speed(10)

2-Grommet to any speed line

6-Grommet = **GS** (110)

7-**WCA** (right=+) = +5

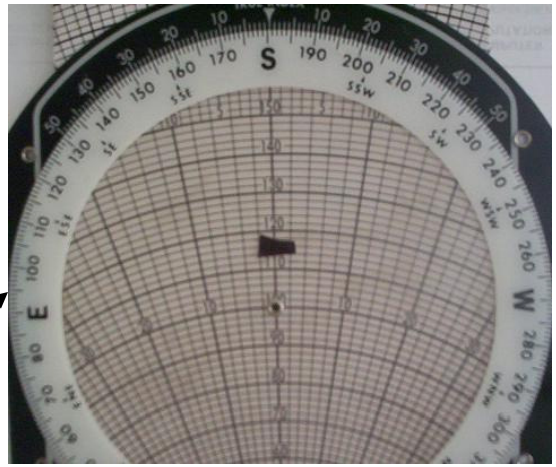
5-Slide card so mark Is on TAS (105)

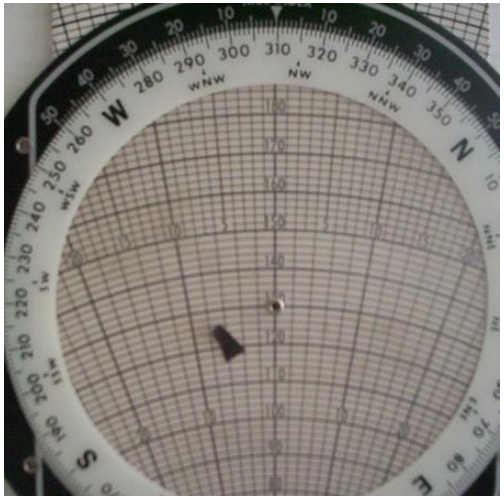
THE FLIGHT COMPUTER
PRACTICE WIND CORRECTION & GROUND SPEED

TRY THIS… TC = 310

TAS = 120

WIND = 180 @ 16





WCA (Wind Correction Angle) -6

TRUE HEADING (TC+/-WCA)? 304

GROUND SPEED? 130

THE FLIGHT COMPUTER
PRACTICE WIND CORRECTION & GROUND SPEED

TC=178

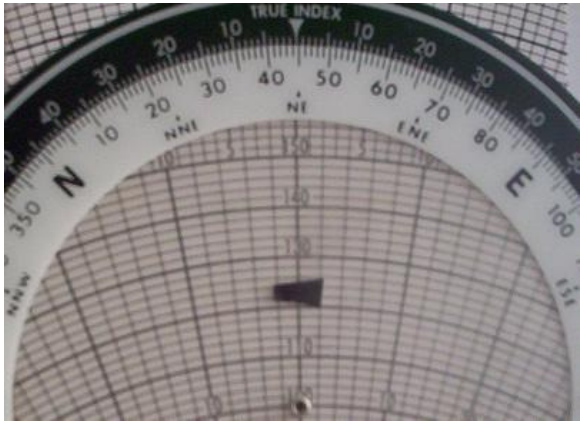
TAS=135

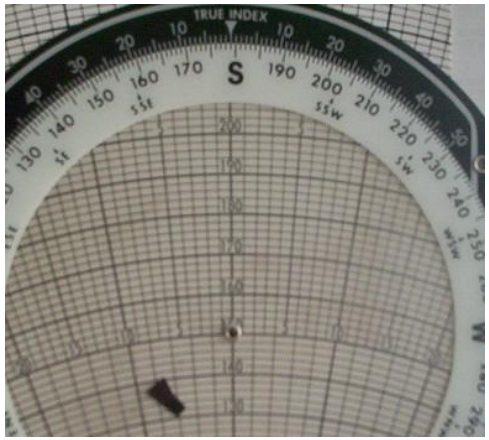
WIND=045 @ 23

WCA (Wind Correction Angle) -7

TRUE HEADING (TC+/-WCA)? 171

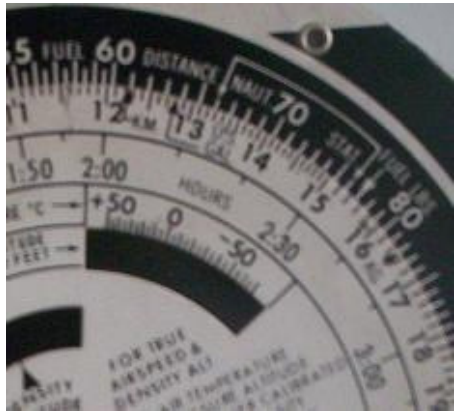
GROUND SPEED? 150

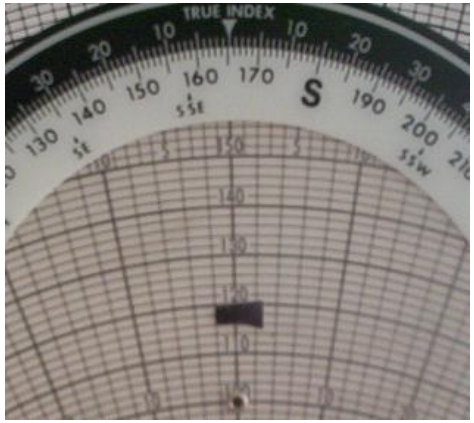




THE FLIGHT COMPUTER
PRACTICE WIND CORRECTION & GROUND SPEED

135 KTS



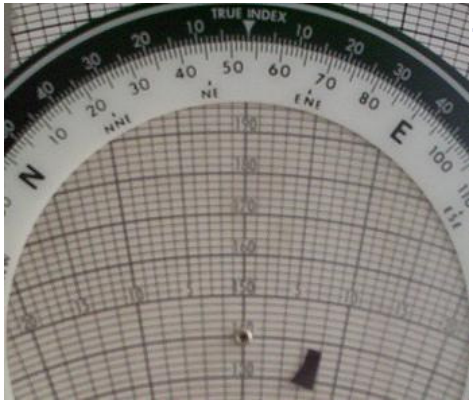


TC=050

TAS=155 **MPH**

WIND=165 @ 18 **KTS**

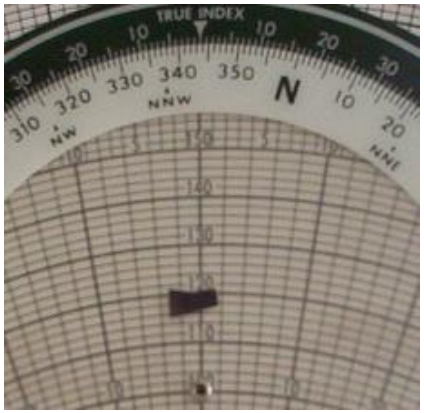
WCA (Wind Correction Angle) +7

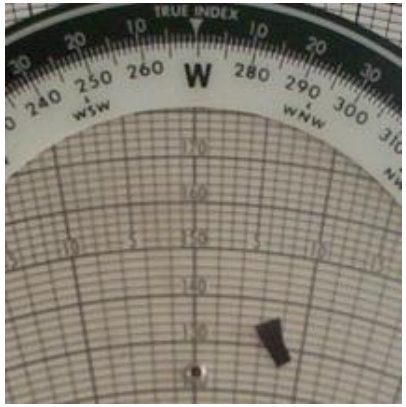


TRUE HEADING (TC+/-WCA)? 057

GROUND SPEED (KTS) ? 142 KTS

THE FLIGHT COMPUTER
PRACTICE WIND CORRECTION & GROUND SPEED





TC=270

TAS=130 KTS

WIND=344 @ 18 KTS

WCA (Wind Correction Angle) +8

TRUE HEADING (TC+/-WCA)? 278

GROUND SPEED? 124 KTS

Determining Wind Direction and Speed using the E6B when enroute.

Basically you ***work the wind problem backwards*** on the E6B.

1. Put your **groundspeed under the grommet**
2. On the **True Airspeed Arc**, put a dot to reflect right or left wind correction angle you are holding.
3. Rotate the ring so that your mark is on the centerline
   Read the wind direction under the E6B True Index
   Read the wind speed as the distance up from the grommet to your mark.

Try this:
Your Heading is 310, but you holding course 304 to maintain the heading.
Your TAS is 120, and your ground speed is 130.
Determine Wind Direction and speed. Slide 55 to confirm your answer.

Wind Direction 180, Wind Speed 16

THE FLIGHT COMPUTER NAVIGATION PROBLEMS

You only need 2 more pieces of the puzzle to plot and compute full navigation problems (Deviation and Variation)

WHAT AND WHERE DO YOU FIND DEVIATION?

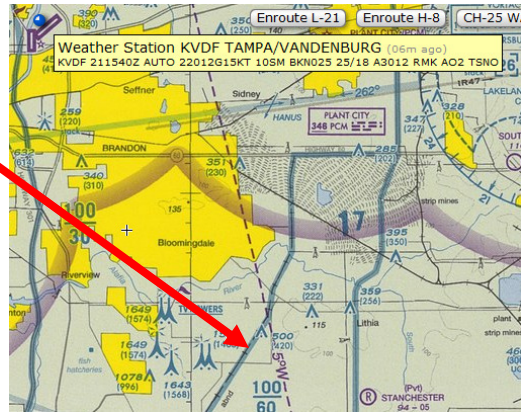
Corrections for instrument errors printed (a) in the POH & (b) on the Magnetic Compass

N6585J Deviation

030	060	090	120	150	180	210	240	270	300	330	360
-1	-2	-1	-1	0	0	+2	+2	+1	0	-1	-1

WHAT IS AND WHERE DO YOU FIND VARIATION?

Variation between TRUE and MAGNETIC North located on Sectional Charts as dashed vertical lines (E & W)



ADD (+) if “W”
SUB (-) if “E”

THE FLIGHT COMPUTER NAVIGATION PROBLEMS

PUTTING IT ALL TOGETHER…. IT'S ON YOUR E6B

- TAS, you must know the Winds Aloft , outside air temperature and velocity <u>at altitude</u>

- WCA is the offset to the TC due to the winds aloft

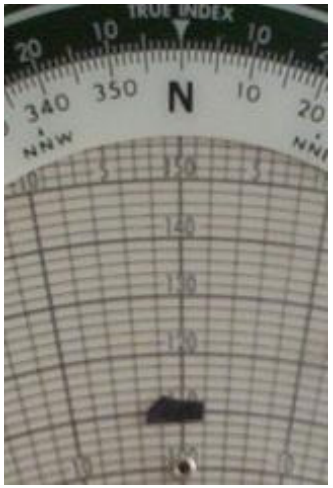
- GS is the correction of TAS for the winds aloft

- TH is the TC correction of WCA (TH = TC +/- WCA)

- MH is the TH correction of Variation (MH = TH +/- VAR)

- CH is the MH correction of Deviation (CH = MH +/- DEV)

THE FLIGHT COMPUTER
PRACTICE WIND CORRECTION & GROUND SPEED



TC=095

IAS=111 KTS

TEMPERATURE = +25 C

ALTITUDE = 7,500

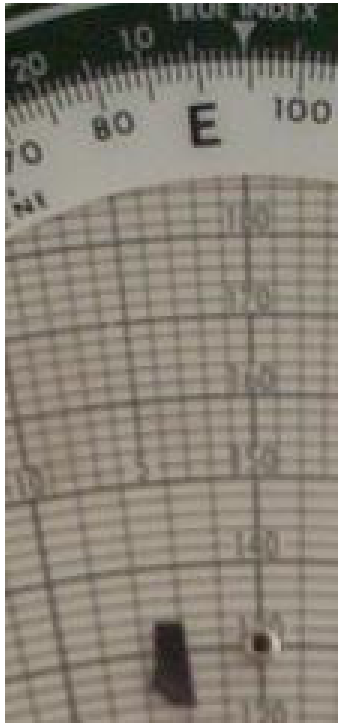
WIND=360 @ 10 KTS

TAS 130 KTS

WCA (Wind Correction Angle) -4

TRUE HEADING (TC+/-WCA)? 091

GROUND SPEED (KTS)? 130 KTS



THE FLIGHT COMPUTER NAVIGATION PROBLEMS

Flight from Vandenberg to Venice FL, TRUE COURSE (TC)=197
WINDS ALOFT = 050 @ 25 KTS, TEMPERATURE ALOFT +10C

IAS = 115 = CAS

ALTITUDE 4,500 DISTANCE = 38 SM

030	060	090	120	150	180	210	240	270	300	330	360
-1	-2	-1	-1	0	0	+2	+2	+1	0	-1	-1

TAS	124
GS	144
WCA	-6
TH (TC +/- WCA)	191
VARIATION 4W	+5
MH (TH+/- VARIATION)	196
DEVIATION =	+1
CH (MH +/- DEV) =	197

THE FLIGHT COMPUTER NAVIGATION PROBLEMS

SAME FLIGHT – DIFFERENT DAY
CAS 115, CRUISING 4500
WIND 200 @ 25, TEMP = +20 C

TC=	197
TAS	127
GS	102
WCA	+1
TH	198
VAR	+5
MH	203
DEV	+1
CH	204

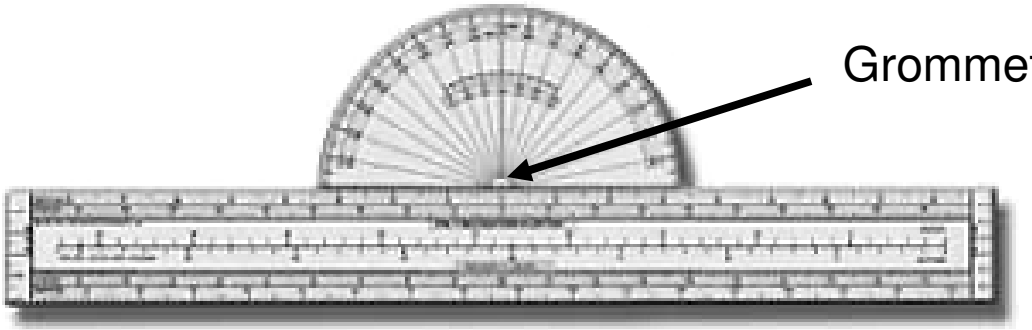
RETURN FLIGHT
WIND 200 @ 25, TEMP = +20 C

TC=	017
TAS	127
GS	152
WCA	-1
TH	016
VAR	+5
MH	021
DEV	-1
CH	020

THE NAVIGATION PLOTTER

1. Use as straight edge to draw course line between airports/navaids
2. Measure DISTANCE

3. Determine TRUE COURSE



C A U T I O N

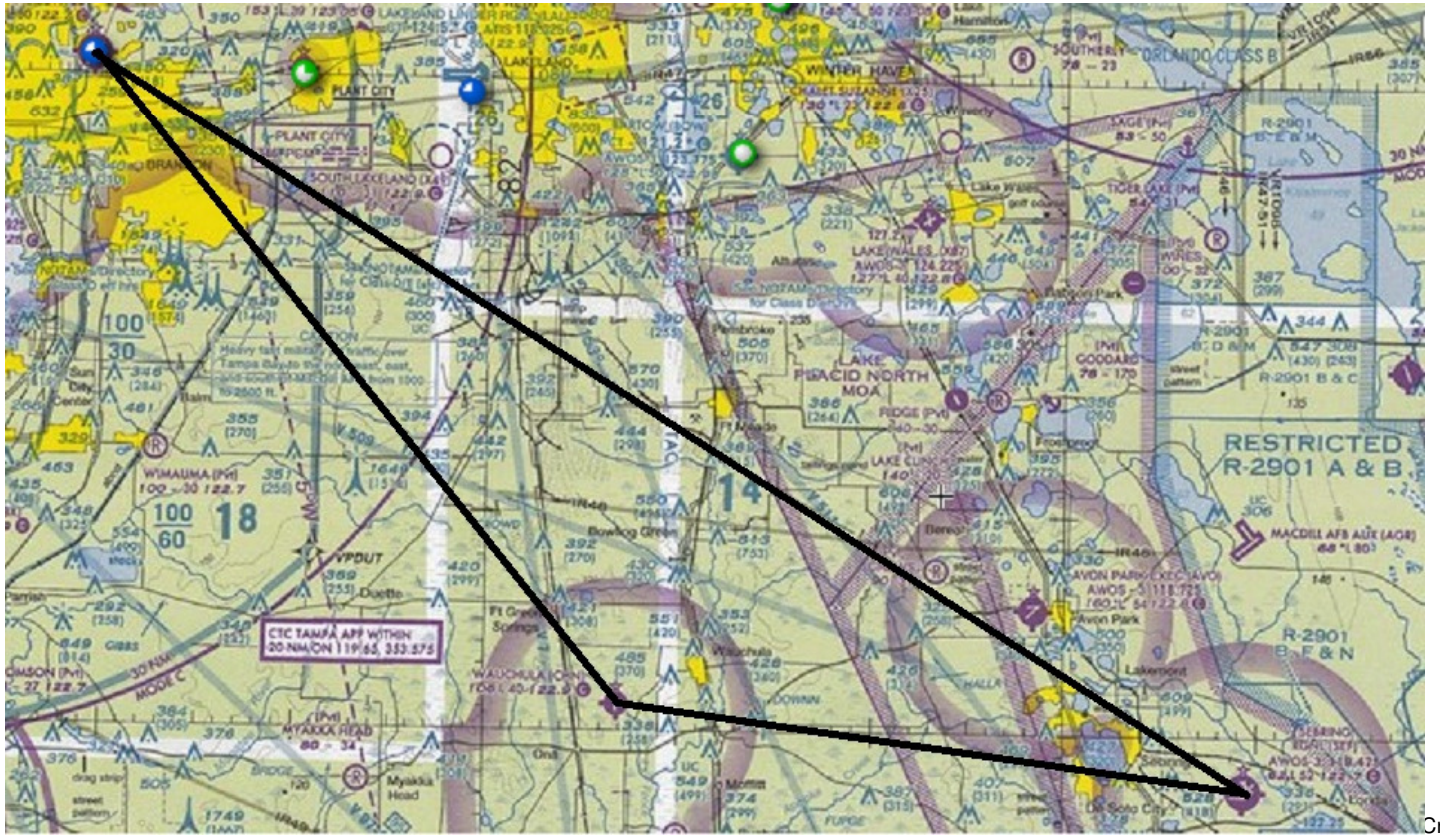
USE THE CORRECT SIDE (SECTIONAL)
USE APPROPRIATE UNITS OF DISTANCE (NM)
USE PENCIL – NOT PEN UNLESS YOUR ABSOLUTELY SURE

NAVIGATION PLOTTER PRACTICE

PRACTICE EXERCISE 1

DRAW COURSE LINE AND RECORD DISTANCE (NM) BETWEEN

LEG 1. Tampa Executive to Sebring Airport.
LEG 2. Sebring Airport to Wachula Airport
LEG 3. Wachula Airport to Tampa Executive Airport

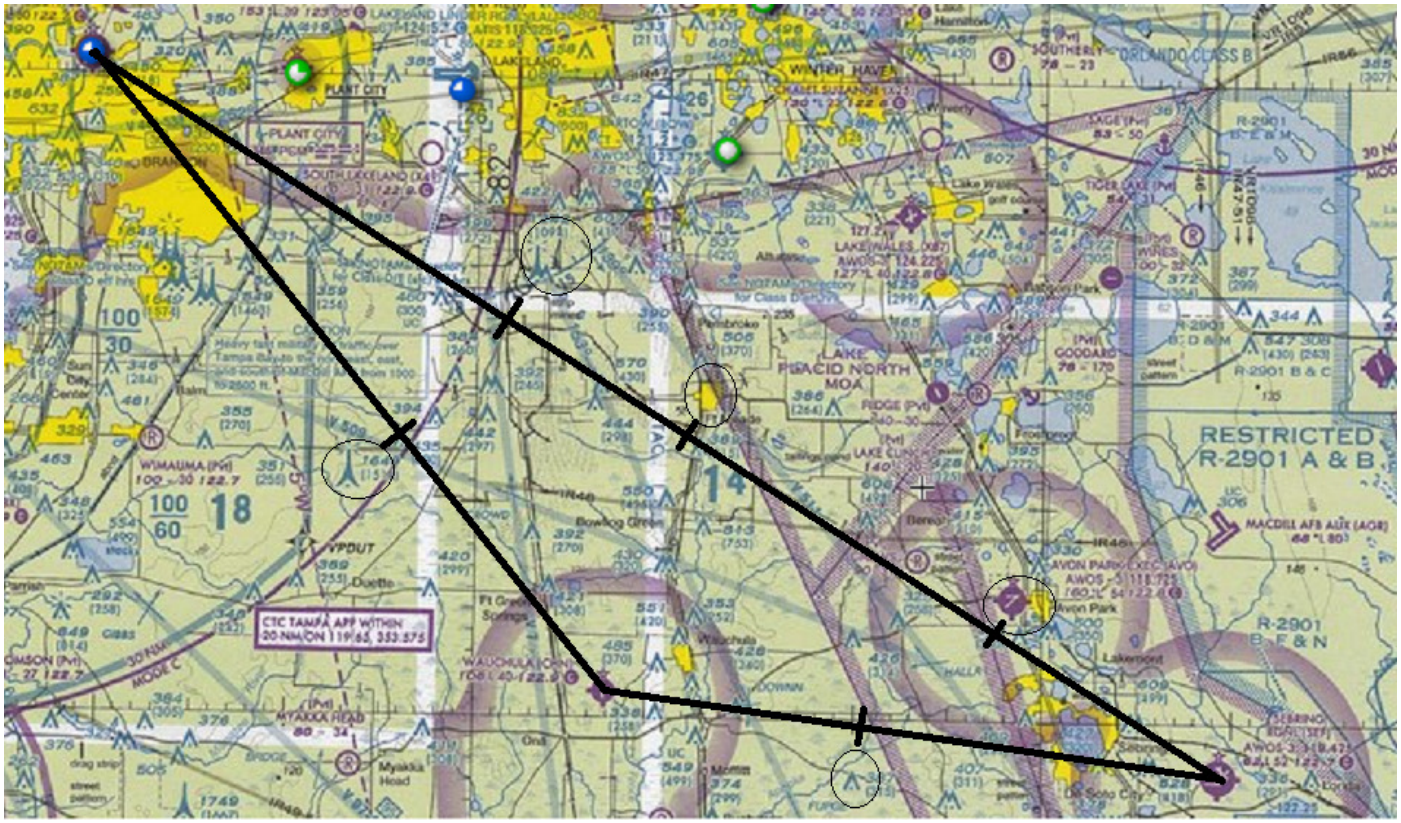


NAVIGATION PLOTTER PRACTICE

PRACTICE EXERCISE 2

Mark and measure Checkpoints for each leg. It is a visual marker of your choice to assist you to recognize if you are on course. It should be a point easy to recognize. Give careful consideration if night – checkpoints will differ at night.

1. Mark your **CHECKPOINTS** for each let of the flight.
2. Record the distances on each leg of the flight. True Courses discussed next class.



Next Session – Cross Country Planning & Navigation

- Study for exam on use of E6B and PN-1.
- Read Chapters 9,Section A and 5, Section A.

BRING A SECTION CHART, E6B, AND PN-1 TO THE NEXT CLASS. Also, in the "Jewel" folder for the "Cross Country-COMM" Section 05, Print 2 "NAVLOGPlan.pdf sheets for our exercises in class.

"That's All Folks"