Flight Computers

Session Time: Three, 50-minute sessions

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

Comprehensive preflight planning is an integral (and regulatory) component of safety for all flights.

Pilots have a variety of methods to compute navigational data including paper-and-pencil, mechanical slide-rule-type computers, and electronic flight computers.

Weather changes rapidly, and pilots must be able to make flight planning and navigation calculations during flight if conditions are different than those forecast in a preflight weather briefing.

ESSENTIAL QUESTIONS

1. How does a pilot use mechanical and electronic flight computers to make flight planning and navigation decisions?

LEARNING GOALS

Students Will Know

- How the E6-B, a manual flight computer, works.
- How a flight computer is used in flight planning.
- How a flight computer is used during flight to adjust navigation calculations.

Students Will Be Able To

- *Calculate* wind correction angle and groundspeed using the E6-B. [DOK-L1]
- *Compare* preflight navigation planning results with in-flight performance. [DOK-L2]
- *Apply the concepts* of the E6-B to determine wind correction angle, heading, and groundspeed. [DOK-L4]

ASSESSMENT EVIDENCE

Warm-up
In pairs, students will summarize the equations learned over several lessons involving heading, time/distance/speed, and fuel use. This emphasis on calculating for flight planning will segue into a discussion on the capability of the E6-B to perform those calculations.

Formative Assessment
In pairs, students will work together to calculate various flight planning parameters using the E6-B flight computer, including application to flight-based scenarios.

Summative Assessment

In pairs, students will work together to plan a flight route between two airports using the spectrum of required flight information from weather to airplane data. They will then fly their route using a simulator and evaluate their calculations. Students will assess the navigation planning performance and synthesize the lesson material to determine if planning was correct and ways planning could be updated while the flight was airborne.

LESSON PREPARATION

MATERIALS/RESOURCES

- Flight Computers Presentation
- Flight Computers Student Activity 1
- Flight Computers Student Activity 2
- Flight Computers Student Activity 3
- Flight Computers Teacher Notes 1
- Flight Computers Teacher Notes 2
- Flight Computers Teacher Notes 3
- **VFR sectional aeronautical chart (any area is suitable, but one covering the local area is preferable)**
- **Aeronautical chart plotter with rotating azimuth wheel**
- **E6-B manual flight computer**

Flight Simulation Activity (Student Activity 3)

- Computer with flight simulation software or flight simulator
- Joystick or yoke
- Optional: Throttle quadrant, rudder pedals, additional monitors

LESSON SUMMARY

Lesson 1: Drawing and Measuring Courses
Lesson 2: Which Way to Steer?
Lesson 3: Flight Computers

The lesson begins with a warm-up that summarizes the equations students have learned in prior lessons, giving them an opportunity to combine the equations for a full flight planning calculation experience. The lesson then introduces the E6-B flight computer, stepping through a series of demonstration/practice examples covering the primary equations necessary for basic route planning.

Students will then work in pairs to develop a flight plan in which appropriate calculations are made using only the E6-B.

Finally, students will plan a route on a chart and then fly it using a simulator to assess their work and evaluate their ability to perform real-time updates.

BACKGROUND

The E6-B mechanical flight computer is a circular slide rule that has existed with little variation since the 1940s. It has continued to be a reliable and simple tool for making flight-planning calculations.

Despite the prevalent use of electronic flight computers, the "whiz wheel," as the E6-B is affectionately known, remains a commonly used flight planning tool. One of the hallmarks of the mechanical E6-B is that no batteries are required for its use. Because the device is unlikely to fail, it is an excellent back-up tool for flight planning. The E6-B is not difficult to use, but like any unfamiliar tool, instruction in its use is required. Fortunately, most whiz wheels come with instruction booklets which will walk the user through the steps for completing various calculations. In addition, there are multiple videos on YouTube that walk users through the steps of how to use the E6-B to perform calculations.

The following video is the introduction to a series of 26 videos by Flight Tutor that cover many calculation capabilities of the E6-B. Note: Viewing the video on YouTube will allow the entire series of videos to be visible in the sidebar, and they will play down the playlist. Using Safe YouTube prevents direct access to the other videos in the series.

- "E6-B Flight Computer: Introduction" (Length 1:15)
  https://video.link/w/OpZw
  For teachers unable to access Safe YouTube links, the video is also available here:
  https://www.youtube.com/watch?v=fGGGkXeTYiU&list=PLC41C23C8FD27677A

Video 8 of Flight Tutor's series shows calculations of ground speed and true heading using the wind scale on the back of the E6-B. This is one of the central parts of this lesson and may be beneficial to view:

- "E6-B Flight Computer: Ground Speed and True Heading" (Length 5:12)
  https://video.link/w/prZw
  For teachers unable to access Safe YouTube links, the video is also available here:
  https://www.youtube.com/watch?v=9QJ6zl_r898&list=PLC41C23C8FD27677A&index=8

This blog gives photos and step-by-step directions for many E6-B functions:

- https://michaelsoroka.com/2014/09/23/mastering-the-mechanical-e6b-in-20-minutes/

A video demonstration of one type of E6-B problem with a large scale E6-B is here:

- "E6B Flight Computer. Time, Speed, & Distance - MzeroA Flight Training" (Length 5:03)
  https://video.link/w/fDZy
  For teachers unable to access Safe YouTube links, the video is also available here:
  https://www.youtube.com/embed/Qhjcb9Y7ZIg?start=37&end=340

On the following site, teachers can access a demonstration tool from the University of North Dakota that will enable teachers to display a fully articulating realistic digital display of an E6-B to the class. The whiz wheel can be manipulated with the mouse and flipped over to calculate winds. To slide the wind mark to the true airspeed (TAS) line during wind calculations, click and hold on the black area around the words "True Index" then slide as necessary. To make a wind dot, click within the large circular area. To clear away the dot, re-click the "wind" tab or flip to the "front" then back to the wind side.

- http://media.aero.und.edu/interactive-trainers/e6b/?q=sliderule

For those with iOS or Android tablets, there are E6-B simulators like Flight Computer Sim, Sparky's E6B, or Free E6B. These provide simulated E6-Bs that can be manipulated and read just like a physical E6-B.

There are also flight planning websites and apps that students may wish to try to confirm results from the manual E6-B. These sites take the numbers as inputs and perform the same math as an E6-B but only display the solution.

Two website examples:

- The E6BX site is a clean, simple site and has a corresponding app: https://e6bx.com/e6b/
- The E6-B Emulator site is a bit older but still performs the proper functions: http://www.csgnetwork.com/e6bcalc.html

Finally, a calculator-like electronic flight computer such as the CX-3 from ASA or the Electronic E6-B from Sporty's Pilot Shop are commonly-used alternatives to a mechanical flight computer. For the purposes of this lesson, these should only be used to verify calculations from the mechanical E6-B, not as a primary source. Directions/demonstrations will need to be provided by the teacher or the owner of the device and are not part of this lesson.

Note regarding the FAA Private Pilot Knowledge Test: Students are permitted to use a flight computer when taking the FAA test. An E6-B flight computer, whether mechanical or electronic, may be used without any issues. Electronic flight computers must have any memory contents erased prior to the beginning of the test. Flight computer apps on mobile devices are not allowed.

Teaching Tips
In preparation for this lesson, teachers should familiarize themselves with the E6-B by reading its instructions and watching some of the following videos before demonstrating the procedures to students. The instructions cover a wide range of the E6-B's capabilities, and some of the capabilities are not required for the students to master at this stage. This lesson focuses on a select few essential functions: time/distance/heading, fuel usage, true airspeed, density altitude, and wind calculations.

These videos and the blog should be shared with the students so they have an additional reference as they practice using the mechanical E6-B flight computer. You may choose to present select portions at your discretion and/or post the links on your teacher website or Google Classroom for students to access.

MISCONCEPTIONS

Students may believe that electronics and apps have made manual flight computers like the E6-B obsolete.

It is true that calculators, digital flight computers, and even smartphone apps can do the same calculations as an E6-B, sometimes with less work by the pilot. Still, the E6-B is a tried and true flight planning tool and retains some advantages over electronic calculators.

First, manual flight computers don't rely on batteries, and they won't fail when the aircraft cabin gets too hot, as some electronics have been known to do. Because of their simplicity, it's sometimes actually faster to do a calculation with the mechanical E6-B than it is to operate software to get the same answer. More practical to the student pilot, FAA examiners may ask private pilot candidates to make a calculation without using an electronic device.

Another more significant advantage to the mechanical E6-B is that it presents a visual representation of the relationships between the values of time, distance, heading, fuel, course, and wind. Rather than input two or three numbers and then see another number as a result, the mechanical E6-B visually depicts the relationship between the values the pilot inputs. This is especially true on the wind calculation side. The mechanical E6-B presents a 2-D picture of the wind's impact on the aircraft, helping the pilot visualize the effect of the winds. This visualization helps pilots understand the calculations behind the numerical results that are displayed by software or apps.

Finally, it is worth noting that multifunction electronic tablets and smartphones cannot be brought into the written FAA Private Pilot Knowledge Test. Student pilots may bring a mechanical E6-B or an electronic E6-B. The memory of an electronic E6-B must be cleared prior to the test.

When learning about and using the mechanical E6-B, pilots understand it's not just to experience the “old way” of doing something. Instead, the purpose of these skills is practical and helpful to understand the concepts behind flight planning calculations.

DIFFERENTIATION

To support student calculation of wind correction angle, set up stations with extended learning opportunities to include instructional videos, sample calculations, and scenarios. Allow students to work with a partner or in small groups. Model the simulation activity in Student Activity 3. Prompt students with guiding questions as you demonstrate how to navigate the simulation.

LEARNING PLAN

ENGAGE

Teacher Materials: Flight Computers Presentation, Flight Computers Teacher Notes 1
Student Material: Flight Computers Student Activity 1

Session 1

Slides 1-3: Introduce the topic and learning objectives of the lesson.

Slide 4: Conduct the **Warm-Up.**

Warm-Up

While advanced mathematics is not required to be a good pilot, some fundamental mathematical skills are helpful, and students have built these skills over the past few lessons. This Warm-Up will summarize and consolidate many of the calculations students have learned, leading into a discussion of how to perform some of them more quickly or with different calculating aids.

Divide the class into pairs and distribute **Flight Computers Student Activity 1**. Students will recall and apply the calculation methods they have learned to date. Sample responses are available in **Flight Computers Teacher Notes 1**.

EXPLORE

Teacher Material: Flight Computers Presentation
Student Material: E6-B manual flight computer

Slide 5: Distribute E6-B manual flight computers to pairs of students, and allow them time to handle and explore the devices. While the class explores the E6-B, consider calling up the online E6-B from the UND website (http://media.aero.und.edu/interactive-trainers/e6b/?q=sliderule) to prepare to demonstrate its operation in the following slides.

Teaching Tips

The mechanical E6-B is actually a circular version of a slide rule, a 'mechanical computer' that existed long before the advent of computer chips and handheld calculators. E6-Bs give pilots the ability to solve virtually any calculation related to flight planning on one machine, no batteries required.

The E6-B derives its name from the military part number it was given when it was created in the 1930s. The current iteration ("E6-B") is a commercial derivation of the military designation E-6B. The "mechanical calculator" or "flight computer" is frequently called a "whiz wheel" by pilots, likely due to its shape and its speedy computational capabilities.

Questions

What did you find on the E6-B? What kinds of functions does the E6-B have?

Responses will vary but may include conversion scales, instructions, highlighted "10," the large pointer arrow on the round scale, formulas, a transparent surface/window, and sliding speed card /scale. Obvious functions include the ability to convert units of temperature, distance, volume, time, and density. Another function is the ability to correct airspeed and altitude for temperature and pressure. The wind side has directions for determining course correction and groundspeed when winds aloft are known.

EXPLAIN

Teacher Material: [Flight Computers Presentation]()
Student Material: E6-B manual flight computer

Slide 6: The following slides present a hands-on, demonstration/performance method of instruction. While still in pairs, students will follow the class demonstration and perform the sample calculation together. Then, each pair of students should solve the problem that appears on the following slide.

Teaching Tips

Throughout the slides, the red arrows mark the first alignment of the wheel, the yellow arrow marks the second number selection, and the green arrow marks the solution.

Because of printing and screen resolutions as well as manufacturing precision, there may be some slight discrepancies between the numbers derived from the on-screen E6-B and the handheld E6-B. In general, the results from the handheld mechanical E6-B should take precedence, but ballpark answers should be acceptable. Alternatively, you may indicate a specific tolerance within which the students' answers must fall (+/- 2 NM for example, if the calculation results in a distance).

If additional practice is required, you may choose to create or post additional practice problems that emulate the samples, or students may be called upon to suggest sample values for additional practice problems.

On the round scale, there are two important reference points. One is the white number 10 within a black square. The other is the arrow at 60. These will be used to set the index and solve the chosen math problem. The index marks will normally point either to the factors of an equation or its solution.

Slides 7-8: The flight computer is ultimately a mechanical calculator that can do basic math. For example, solving multiplication problems like 7 5 requires the following steps:

Set the 10-index on the inner scale to the first factor (70) on the outer scale. Note that there is no 7 on the outer scale. On the inner scale, find the second factor (5, but note there is no 5, so use 50). Note that the decimal place or order of magnitude of the factors and solution is understood by logic or common sense. On the outer scale next to the 5 is the solution: 35.

Inform students that they can think of the 10-index on the movable wheel as a multiplication sign in problems like this.

Teaching Tips

It is important for students to note the markings on the outer ring when looking for the answer. For example, in solving 4 x 8, the mark for 8 falls on a line that could be mistaken for 34; however, if students look at the scale divisions carefully, they will note that it is actually 32. There are 10 divisions between the numbers 30 and 35 on the outer ring.

Slide 9: Solving division problems uses the same logic, but in reverse. Solving 117 / 9 requires the following steps:

Rotate the wheel to put the divisor (9) on the inside scale opposite the dividend (117) on the outside scale. Now find the 10- index on the inside scale, which is aligned with 13 on the outside scale. The quotient (answer) is 13. The slide shows an image of the E6-B aligned correctly to display the answer.

Students may return to the flight planning calculations in the Warm-Up and use the E6-B to solve them for additional practice.

Slide 10: The flight computer is built to make flight planning calculations more intuitive and even has explanations of common flight equations written on its face. For example, for time, speed, and distance, set the Rate index to the speed and read time on the inside scale. The distance is read on the outside scale.

To solve how far an aircraft flies at 135 knots GS in 2 hours and 10 minutes it could be done as the math problem 135 2.17. But using the described method, set the arrow to the speed (135 knots). The other known value is time. The inner scale is in minutes (or there is a subscale inside the minutes that reads in hours and minutes). Find 130 minutes (2 hours and 10 minutes) on the inner scale, and notice that 130 aligns with approximately 292 NM. (The actual answer is 292.5, which is a level of precision not readable on the E6-B.)

Teaching Tips

Manufacturing inconsistencies may mean that the marks on the E6-B do not align to the exact answer. For example, in one trial, the online E6-B emulator, a paper E6-B, and a metal E6-B all had slightly different indications with the metal device providing the most accurate answer. This reinforces the fact that any answers to assessment questions should be given some leeway. Of course, this is also a reason that some may argue why electronic devices are best.

Slide 11: To solve distance when GS = 200 knots and flight time = 45 minutes, align the arrow to 200 (the 20 mark). Find 45 on inner scale, and it aligns with 15 on the outer scale. Using logic for decimals, this correctly displays 150 NM. Think: If an aircraft covers 200 NM in one hour, then in of an hour (45 minutes), it should cover of 200 NM, or 150 NM. The slide has an image of the E6-B correctly spun to the solution.

This same method can be used to solve for any of the three variables in the time, distance, speed problem.

Slide 12: To solve for the groundspeed (GS) of an aircraft that travels 350 NM in 1 hour and 45 minutes, align the known values (350, 1:45) on the outer and inner scales, and the Rate index arrow will point to the speed (20, or 200 knots). Note: 1 hour and 45 minutes can also be translated to 105 minutes on the middle scale.

Slide 13: To solve for GS when the distance is 100 NM in 1 hour and 15 minutes, align 100 on the outer ring with 1:15 on inner scale (or 75 on the middle scale—1 hour and 15 minutes is equal to 75 minutes), and the arrow points to 80 knots. The slide has an image of the E6-B correctly spun to the solution.

Slide 14: The process for solving for time is the same. To solve for time when an aircraft is traveling at 115 knots for 180 NM, put the Rate index arrow on the speed, find the distance on the outer ring (18) and read the time (1:34).

Slide 15: To solve for time when GS is 125 knots and the distance is 100 NM, set the Rate arrow index to 125, find 100 NM on the outer scale, and read 48 minutes on the middle scale. The slide has an image of the E6-B correctly spun to the solution.

> **Teaching Tips**
>
> When times are less than one hour, the inner scale is still usable, but some mental math is required. For example, in the problem on Slide 15, the inner scale 8:00 lines up with 100 NM. This is not 8 hours of course, but it is 8/10 of one hour: 0.8 x 60 minutes = 48 minutes.

Slide 16: The process for fuel calculations is similar, with rate, time, and fuel used on the same scales as speed, time, and distance traveled.

To find the fuel used when the fuel consumption rate is 18 gallons per hour over 3 hours and 40 minutes, set the Rate arrow on the fuel consumption rate, then find the other factor: fuel consumed will be on the outer scale, time on the inner scale. With the Rate arrow on 18, the inside scale of 3:40 aligns with 66 gallons.

Slide 17: To solve for fuel used at a rate of 8 GPH over 1 hour and 15 minutes, set the Rate arrow on 8, find 1:15 on the inner scale, and see that it aligns with 10 on the outer scale, for 10 gallons. The slide has an image of the E6-B correctly spun to the solution.

Slide 18: As with time/distance/speed, a similar process is used when using the variables in time/fuel used/fuel consumed rate problems.

To determine the fuel consumption rate after 30 gallons are used in 115 minutes, align 30 gallons (outer scale) with time of 115 minutes (inner scale), and the Rate arrow points to 15.7 GPH.

Slide 19: To find the fuel consumption rate when 11 gallons is used in 1 hour and 10 minutes, align 11 (outer scale) with 1: 10 (inner scale), and the Rate arrow points to a fuel consumption rate of 9.4 GPH. The slide has an image of the E6-B correctly spun to the solution.

Slide 20: The E6-B can also solve multi-step problems by skipping intermediate steps. For example, if 45 gallons of fuel are used in 4 hours and 15 minutes, how much more flight time does the aircraft have if it has another 20 gallons available? Rather than solving for the fuel consumption rate in the first step and applying it to the second step, the E6-B allows the pilot to jump directly to the solution.

To solve this example problem, align 45 on the outer scale with 4 hours and 15 minutes on the inner scale. Finding 20 gallons on the outer scale aligns with 1 hour and 52 minutes on the inner scale. It is not necessary to determine the fuel consumption rate, though it does appear under the arrow at 10.6 GPH.

Slide 21: To determine how much additional flight time is available when 10 gallons of fuel remain after 12 gallons have been consumed in 1 hour and 15 minutes, align 12 on the outer scale with 1 hour and 15 minutes on the inner scale. Looking under 10 gallons on the outer scale, the students should find 62.5 minutes on the middle scale. The slide has an image of the E6-B correctly spun to the solution.

Slide 22: The small windows closer to the center of the wheel provide the pilot the ability to make calculations regarding true airspeed, temperature, pressure altitude, and density altitude.

For example, given pressure altitude and the outside air temperature (OAT), the pilot can align these values in the small windows, and the middle scale of the wheel becomes calibrated airspeed, and the outer scale becomes true airspeed.

The E6-B may have the instructions for this calculation written on the face.

To solve for true airspeed at 120 knots calibrated airspeed at 3,000 feet pressure altitude with an outside air temperature of 0 degrees C, align the 0 deg C mark and the 3,000 ft pressure altitude mark, and then find 120 knots on the middle scale. It aligns with 123 knots on the outer scale, for a 123-knot true airspeed. Simultaneously, the density altitude for these conditions appears on the inner window.

Slide 23: To solve for density altitude if the pilot is at 4,000 feet pressure altitude and the OAT is –10 deg C, align pressure altitude of "4" with temperature of –10 in the small window, then read "1.5" in density altitude window; apply logic to the decimal and read it as 1500 feet. (Due to the small scale of the window, it is easy to read this value as 2,000 ft.) The slide has an image of the E6-B correctly spun to the solution.

Slides 24-26: The opposite side of the E6-B provides a handy method of solving the wind triangle learned in previous lessons. The E6-B likely includes instructions at the top of the sliding scale. The face of the transparent wind disk is made of a plastic that can be written on with a pencil, and the pencil marks erase easily for repeated use.

For an airspeed of 135 knots, TC of 335°, wind of 055° at 27 knots, what is the GS and WCA?

1. Turn the transparent disk until the wind direction is under the True Index. Slide the scale until the center grommet aligns with (any) horizontal line for reference. Handy Hint: Before marking the wind speed, place a round number like 100 or 200 under the grommet. Now marking a number like 27 is easy—just place the mark at 127 or 227.
2. Using the grid lines, count up from the grommet and mark the wind velocity with a dot or the letter T. Use a pencil, and the mark can be erased when complete. Using a T rather than a dot will remind you that the winds were true but also remind you of the orientation, as the T will be inverted if the wind becomes a tailwind.
3. Turn the transparent disk until the TC is under the True Index.
4. Slide the scale until the wind dot or T falls on the horizontal line representing your TAS.

The groundspeed can be read as the horizontal line under the grommet: 128 knots. The WCA is the angle between the centerline and wind mark: 11° to the right.

Assuming a magnetic variation (VAR) of 5°E and a magnetic deviation (DEV) of 0°, pilots can simply follow the equations to find the CH. In this case, TH = 346°, MH = 341° = CH.

EXTEND

Teacher Materials: Flight Computers Presentation, Flight Computers Teacher Notes 2
Student Materials: Flight Computers Student Activity 2, E6-B manual flight computer

Session 2

Slide 27: The slide presents a scenario for the students to use all of the calculations from this lesson in a single setting, as they would in an actual flight plan. Continue to allow the students to work in pairs. You may permit them to check their work with an online or electronic E6-B as they progress. Consider stopping the students at intervals to share their progress with the group to ensure accuracy. The scenario on the slide is reproduced below.

“You are traveling from Blue Municipal Airport to Earhart Regional, a distance of 325 NM. You have planned a TC of 340° and a TAS of 145 knots. The aircraft will consume 10 GPH at that power setting. You've checked the weather, and the skies are clear with winds aloft of 300° at 20. The VAR for your local area is 4°E, and your aircraft's compass card says, "For 330°, Steer 328°."

What compass heading should you fly, how long will it take you to get there, and how much fuel will you consume on the flight?

Start by solving the wind on the back side of the E6-B. Using the steps listed above and the data provided, the GS is 130 knots and the WCA is 5° left.

Thus, the CH = TC – WCA – VAR – DEV = 340 – 5 – 4 – 2 = 329°. Using the E6-B, set the arrow on the GS of 130, and the distance of 325 on the outside scale aligns with 2:30 hours on the time scale. Then, set the arrow to the GPH of 10, and the time of 2:30 aligns with the outside scale fuel used of 25 gallons.

Slide 28: Complete the **Formative Assessment**.

Formative Assessment

If time is available, distribute **Flight Computers Student Activity 2**. Students will work in pairs to exercise their knowledge of the E6-B with example problems that represent the principles discussed thus far. If class time does not permit, consider assigning the activity as a homework assignment. Sample responses are available in **Flight Computers Teacher Notes 2**. You may also consider using this activity as a quiz.

[DOK-L2; *compare*], [DOK-L4; *apply concepts*]

EVALUATE

Teacher Materials: Flight Computers Presentation, Flight Computers Teacher Notes 3
Student Materials: Flight Computers Student Activity 3, **E6-B manual flight computer**

Session 3

Slides 29-48: Review the Private Pilot Knowledge Test questions.

Slide 49: Conduct the **Summative Assessment**.

Summative Assessment

Distribute **Flight Computers Student Activity 3**. In this summative assessment, students will work in pairs to plan and fly a route between two airports, with a calculated course, heading, and time. Sample responses are available in **Flight Computers Teacher Notes 3**.

[DOK-L4; *apply concepts*]

Summative Assessment Scoring Rubric

- Follows assignment instructions
- Postings show evidence of one or more of the following:
  - Correct recall of E6-B operations
  - Reasonable application of E6-B operations and results to flight scenarios

    - Evidence and explanation of the above that demonstrate understanding of the material
- Contributions show understanding of the concepts covered in the lesson
- Contributions show in-depth thinking including analysis or synthesis of lesson objectives

Points **Performance Levels**

9-10 Correctly understands all E6-B operations and makes reasonable application and analysis of those operations to flight conditions, with adequate explanation.
7-8 Correctly understands most E6-B operations, with some
errors, and makes generally reasonable application and analysis of those operations to flight conditions, with some incomplete analysis or errors.
5-6 Correctly understands some E6-B operations, with errors, or makes generally reasonable application and analysis of those operations to flight conditions but lacks adequate explanation.
0-4 Provides few, if any, correct ideas about E6-B operations, and/or makes poor application and analysis of those operations to flight conditions with inadequate explanation.

STANDARDS ALIGNMENT

NGSS STANDARDS

Three-Dimensional Learning

- **HS-ETS1-4** - Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
    - Science and Engineering Practices
        - Using Mathematics and Computational Thinking
    - Disciplinary Core Ideas
        - ETS1.B: Developing Possible Solutions
    - Crosscutting Concepts
        - Systems and System Models

COMMON CORE STATE STANDARDS

- **RST.11-12.2** - Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- **RST.11-12.4** - Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11-12 texts and topics*.
- **WHST.11-12.6** - Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

- **WHST.11-12.8** - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
- **WHST.11-12.9** - Draw evidence from informational texts to support analysis, reflection, and research

FAA AIRMAN CERTIFICATION STANDARDS

PRIVATE PILOT

I. Preflight Preparation

Task D. Cross-Country Flight Planning

- Knowledge - The applicant demonstrates understanding of:
    - **PA.I.D.K1** Route planning
    - **PA.I.D.K2** Altitude selection accounting for terrain and obstacles, glide distance of the airplane, VFR cruising altitudes, and the effect of wind.
    - **PA.I.D.K3a** Time, climb and descent rates, course, distance, heading, true airspeed, and groundspeed
    - **PA.I.D.K3b** Estimated time of arrival to include conversion to universal coordinated time (UTC)
    - **PA.I.D.K3c** Fuel requirements, to include reserve
- Skills - The applicant demonstrates the ability to:
    - **PA.I.D.S1** Prepare, present, and explain a cross-country flight plan assigned by the evaluator including a risk analysis based on real-time weather, to the first fuel stop.
    - **PA.I.D.S2** Apply pertinent information from appropriate and current aeronautical charts, Chart Supplements; NOTAMs relative to airport, runway and taxiway closures; and other flight publications.
    - **PA.I.D.S3** Create a navigation plan and simulate filing a VFR flight plan

VI. Navigation

Task A. Pilotage and Dead Reckoning

- Knowledge - The applicant demonstrates understanding of:
    - **PA.VI.A.K1** Pilotage and dead reckoning.
    - **PA.VI.A.K2** Magnetic compass errors.
    - **PA.VI.A.K4a** Selection of appropriate route
    - **PA.VI.A.K5a** Plotting a course, to include determining heading, speed, and course
    - **PA.VI.A.K5b** Wind correction angle
    - **PA.VI.A.K5c** Plotting a course, to include estimating time, speed, and distance
    - **PA.VI.A.K7** Planned versus actual flight plan calculations and required corrections.
- Skills - The applicant demonstrates the ability to:

- **PA.VI.A.S3** Navigate by means of pre-computed headings, groundspeeds, and elapsed time.

REFERENCES

"E6-B Flight Computer: Introduction"
https://www.youtube.com/watch?v=fGGGkXeTYiU&list=PLC41C23C8FD27677A

"E6-B Flight Computer: Ground Speed and True Heading"
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