NAVAL AIR TRAINING COMMAND

INTRODUCTION, CONSTRUCTION, AND DESIGN CHARACTERISTICS OF THE T-28

UC 01 03 01 01 EL

CNAT P-1063 (Rev. 6-82) PAT

T-28 AERODYNAMICS
PRIMARY

1982

NAVAL AIR STATION · CORPUS CHRISTI, TEXAS

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1. CNAT P-1063 (Rev. 06-82) PAT, "Introduction, Construction and Design Characteristics of the T-28, UC 01 03 01 01 EL, T-28 Aerodynamics, Primary," is promulgated for information, standardization of instruction, and guidance of instructors and students in the Naval Air Training Command.

2. This publication will be used to implement the academic portion of the T-28 Primary curriculum.

3. This publication was prepared by Mr. R. L. Sellman, Training Specialist, NAS Corpus Christi, Texas.

4. Recommendations for changes shall be submitted to the Commander, Training Air Wing FOUR.

5. CNAT P-1063 (Ref. 12-76) PAT is hereby canceled and superseded.

Joe L Shaw

J. L. SHAW
Assistant Chief of Staff for
Training and Operations

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PROGRAMED INSTRUCTIONAL SEQUENCES 1

INSTRUCTIONAL OBJECTIVES

1.0 Upon completion of this unit the student pilot will understand the construction and design characteristics of the T-28B including factors affecting wing design. The student will demonstrate this knowledge with a minimum proficiency of 85% on a unit criterion examination.

1.1 Define the conditions under which the T-28 engine will develope 1425 BHP.

1.2 Describe the type of propeller used on the T-28.

1.3 Recall the differences between the "B" and "C" propellers.

1.4 List the dimension for the wing span and wing area of the T-28 aircraft.

1.5 Recall the type fuselage construction of the T-28.

1.6 Recall the type wing construction of the T-28.

1.7 Describe the purpose for setting the thrust line 5 degrees below the longitudinal reference line and its relationship to stability.

1.8 Describe the change of attitude of the T-28 brought about by extending the speed brake and the corrective action required.

1.9 Recall the type high lift device used on the T-28, and describe its effect on lift and angle of attack at the stall.

1.10 Describe the relationship of the vertical fin to the relative wind at design cruise speed and power, with change in power settings, and with change in airspeed.

1.11 Recall the design features used on the T-28 wing and their effects.

1.12 Compute the AR and wing loading for a T-28 wing.

1.13 Recall the factors that determine the glide performance for an aircraft.

1.14 State the method used to obtain washout in the T-28 wing.

1.15 Identify the T-28 engine by official designation.

1.16 Describe the change of attitude of the T-28 caused by extending the wing flaps and the corrective action required.

INSTRUCTIONAL PROCEDURES

The following procedures must be followed to complete this unit successfully.

STEP 1. Read the instructional objectives.

STEP 2. Turn to the programed instructional sequence beginning on page 1 of this booklet; study the instructional material and answer all questions. The correct responses to the questions are found at the end of each frame.

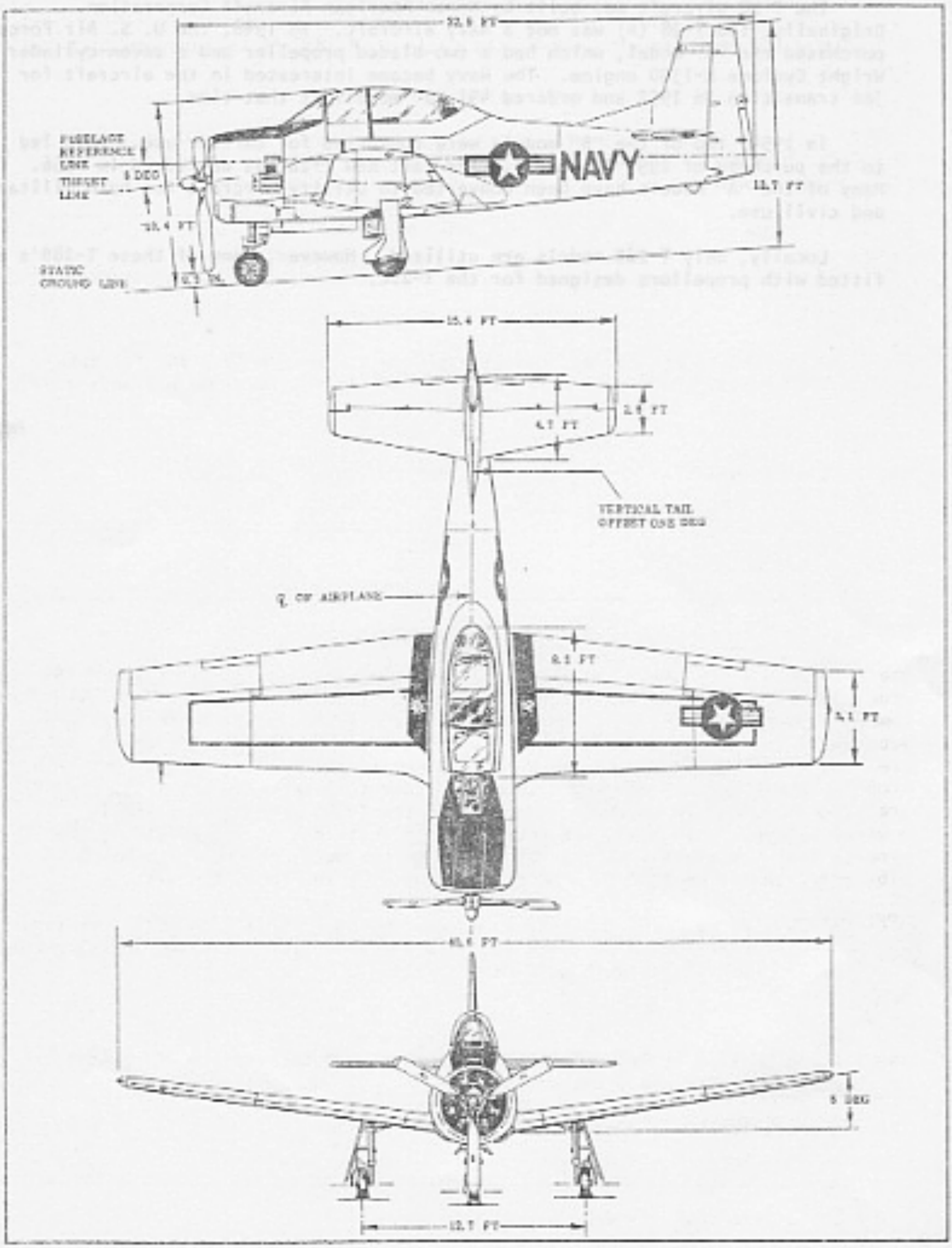
STEP 3. Request the criterion test from the study center instructor-evaluator.

INTRODUCTION TO THE T-28

The T-28 aircraft was built by North American Aircraft Corporation. Originally, the T-28 (A) was not a Navy aircraft. In 1948, the U. S. Air Force purchased the "A" model, which had a two-bladed propeller and a seven-cylinder Wright Cyclone R-1300 engine. The Navy became interested in the aircraft for jet transition in 1952 and ordered 491 "B" models at that time.

In 1954, two of the "B" models were converted for carrier use. This led to the purchase of 299 "C" models. The last new T-28 was delivered in 1956. Many of the "A" models have been converted to utility aircraft for both military and civil use.

Locally, only T-28B models are utilized. However, many of these T-28B's are fitted with propellors designed for the T-28C.


FUSELAGE REFERENCE LINE
THRUST LINE
STATIC GROUND LINE
NAVY
VERTICAL TAIL OFFSET ONE DEG
5 DEG

FRAME 1

The Navy versions of the T-28 are much more powerful than was the Air Force model, since they are equipped with the Wright Cyclone, R-1820-86 engine, manufactured by Lycoming.

- - - - - - - - - - - - -

The T-28 "B" and "C" aircraft have an R- _________ - _________ engine

---

1820

FRAME 2

This nine cylinder, air cooled, radial engine will develop 1425 BHP for take-off at 2700 r.p.m. (full increase) and 52.5" MAP at sea level on a standard day.

- - - - - - - - - - - - -

The R-1820-86 engine is rated at _______ BHP for takeoff at r.p.m.

1425 . . . 2700

FRAME 3

The T-28B and T-28C use a Hamilton Standard, three-bladed, constant speed, hydromatic propeller. The T-28B propeller has a diameter of 10 feet 1 inch. To prevent prop damage on arrested landings, the diameter of the T-28C prop had to be reduced. Because of the reduction in diameter of the T-28C prop (9 feet 4 inches), the prop area was insufficient for the brake horsepower of the engine. To correct this problem, the blades of the T-28C prop are wider than those on the T-28B prop and are stronger close to the hub. This causes the T-28C prop to be slightly heavier. A wider square tipped blade has increased tip vortices, for this reason, the "C" prop is less efficient than the "B" prop. On the deck, the "C" prop has a vibration range from 1900 to 2200 r.p.m. caused by the above factors.

(APPLICATION: *Since local training squadrons employ T-28B's with both type props, care should be taken to avoid the 1900-2200 rpm range during ground operations with a "C prop" aircraft.*)

- - - - - - - - - - - - -

The T-28C propeller is less efficient than the T-28B because the "C" blades are _____________ and the diameter is _________.

The "C" propeller has a vibration on the deck between _____________ r.p.m.

---

wider . . . less . . . 1900-2200

FRAME 4

You must know the dimensions for the T-28 wing span and the wing area. The wing span for the T-28 is 40.59 feet and the wing area is 271.05 square feet.

- - - - - - - - - - - - -

The T-28 wing span is __________ feet and the wing area is __________ square feet.

40.59 . . . 271.05

FRAME 5

The construction of the aircraft is all metal, including control surfaces and flaps. The wing is a full cantilever (no external braces) of two-spar construction and is mounted on the lower side of the fuselage with 8-degree dihedral. The fuselage is a semimonocoque (fuselage shell carries only part of the stress) and is constructed in two major sections. Only four stringers help the skin withstand stress placed on the fuselage by G loading.

- - - - - - - - - - - - -

The construction of the T-28 is all metal, with a full __________ wing and __________ fuselage.

cantilever . . .semimonocoque

FRAME 6

The thrust line of the T-28 is inclined 5°. This puts the thrust line below the longitudinal reference line or above the center of gravity. Inclining the thrust line reduces the destabilizing effect of power changes.

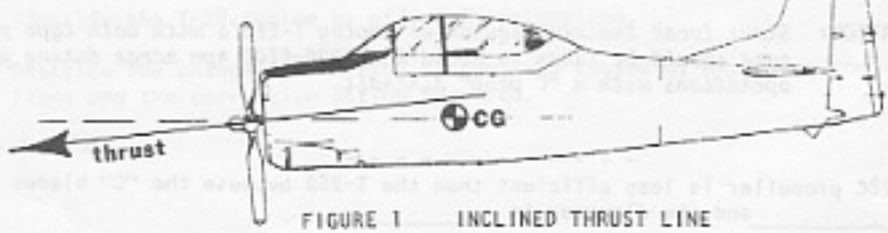


FIGURE 1 INCLINED THRUST LINE

- - - - - - - - - - - - -

The thrust line, being above the center of gravity, will __________ the destabilizing effect of __________ changes.

reduce . . . power

FRAME 7

The speed brake is mounted on the underside of the fuselage, aft of the main landing gear. The operation of the speed brake is by an electrical switch on the throttle grip. The brake has only two positions --full up (off) or full down (on). Extending the speed brake reduces the pressure under the horizontal stabilizer. When the brake is extended, the nose of the plane pitches up. The pitch-up can be counteracted by forward stick force. The manufacturer places no restriction on speed brake use. The Navy has found that the violent nose-up pitch above 250 knots may cause the pilot to lose control of the aircraft. For this reason, the speed brake should not be extended above 250 knots.

- - - - - - - - - - - - - - - -

Extending the speed brake will cause the nose to ______________________.

---

pitch up

FRAME 8

The T-28's prop creates a swirling slipstream wich strikes the left side of the vertical fin. The vector sum of the prop-swirl wind and the free airstream wind at the appropriate power for design cruise airspeed lays one degree to the left ot the T-28's centerline. Hence, the T-28's vertical fin is offset one degree left (see aircraft schematic, page 2).
Since the prop swirl wind is a function of power, and since the free airstream wind is a function of airspeed, a left or right yawing moment will result if conditions are other than design cruise airspeed/appropriate power.

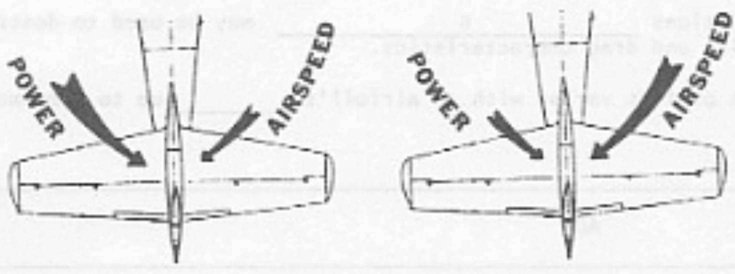


FIGURE 2 POWER/AIRSPEED YAW

APPLICATION: *High power settings at low airspeeds* (TAKEOFF ROLL, CLIMB) *will result in a left yawing moment which must be counteracted with right rudder.*

- - - - - - - - - - - - -

If airspeed is increased with no comparable power setting adjustment, the relative wind will strike the vertical stabilizer from the __________side.

---

right

FRAME 9

Coefficient of lift (C_L) is a relative measure of an airfoil's lifting capabilities. C_L varies with an airfoil's angle of attack (AOA) up to some maximum value ($C_L max$). Comparatively high lift airfoils may have a C_L max of 1.8, while thin airfoils (such as might be used on a jet) may have a C_L max of only 0.9. The T-28 wing (flaps up) has a C_L max of 1.3. (See Figure 3A)

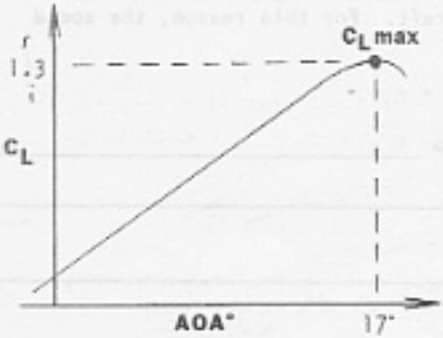


FIGURE 3a T-28 C_L

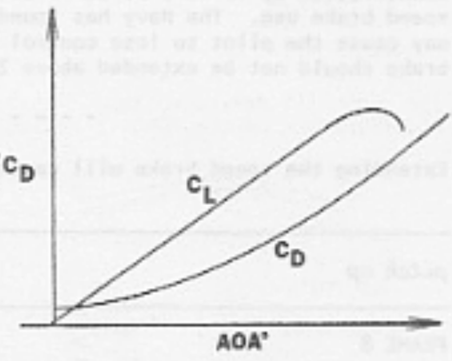


FIGURE 3b C_L&C_D

A similar concept used in the study of aerodynamics is coefficient of drag (C_D). C_D is a function of an object's "streamlining", and also of any lift that object might produce. Figure 3B shows the relationship of C_L and C_D for a typical airfoil.

- - - - - - - - - - - - -

The abbreviations ________ & ________ may be used to describe an airfoil's relative lift and drag characteristics.

Coefficient of lift varies with an airfoil's ________ up to some maximum point ($C_L$max).

C_L & C_D AOA

FRAME 10

The lift a wing will produce (the weight it will carry) may be computed by the lift equation

$$L = \frac{V^2 \sigma S C_L}{295}$$

where L = lift (pounds)

σ = density ratio (ratio of ambient (surrounding) air density to sea level air density) (see T-28 NATOPS pg 11-8) (σ = 1 at sea level)

S = wing surface area (ft^2)
V = velocity (knots)
C_L = Coefficient of Lift (Frame 9)

Compute lift using the following information:

C_L=0.6, σ = 1.0 (sea level), wing area 271 ft^2, TAS = 150 kts

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12402

FRAME 11

The high lift device of the T-28 is a slotted flap. High-energy air from the lower surface of the wing is ducted to the upper surface of the flap (Figure 4).

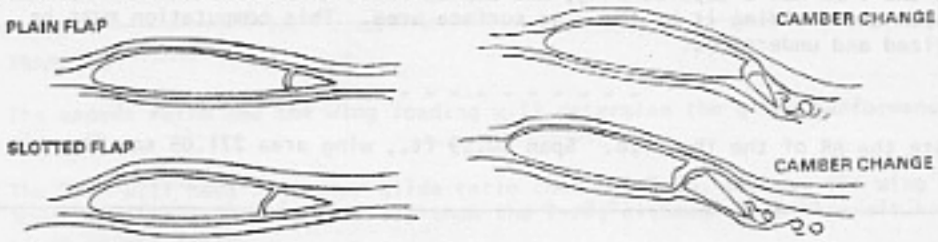


FIGURE 4 PLAIN & SLOTTED FLAPS

The high-energy air from the slot accelerates the upper surface boundary layer and delays airflow separation (hence, stall) to some higher C_L than would occur on an equivalent plain flap (figure 5A). Also, for any given value of C_L, the slotted flap generates a lower C_D than it's plain equivalent (figure 5B). Finally a slotted flap will achieve a greater $C_L$max than a plain flap.

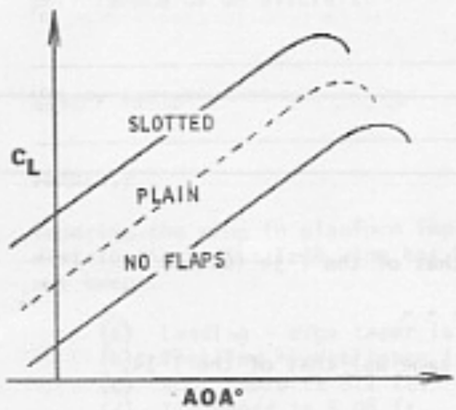


FIGURE 5a FLAPS & C_L

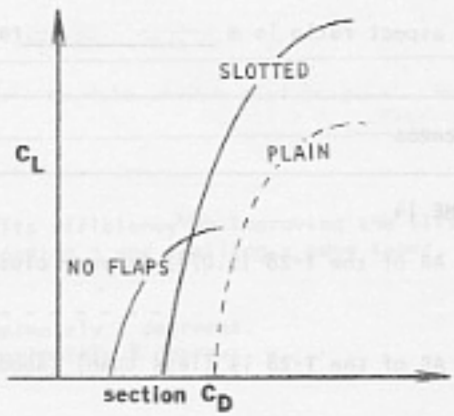


FIGURE 5b FLAPS & C_D

With flaps down, the camber of the wing is greater, and the T-28 will stall at <u>lower</u> angle of attack. Lowering the flaps increases the camber on the after section of the wing - causing a nose down pitching moment.

(APPLICATION: *When lowering flaps in the T-28, one may expect a nose-up pitch which will have to be counteracted with forward stick.*)

- - - - - - - - - - - - - -

A comparison of the slotted and plain flap shows that the $C_L$max for the slotted flap is________________.

Section drag for the sloted flap is__________than section drag for an equivalent plain flap.

---

greater, less

FRAME 12

Aspect ratio in its simplest form is the ratio of length to width of a wing. Since the T-28 has a tapered wing, the aspect ratio (AR) is determined by squaring the span and dividing it by the wing surface area. This computation must be memorized and understood.

- - - - - - - - - - - - -

Compute the AR of the the T-28. Span 40.59 ft., wing area 271.05 sq. ft.

6.078

FRAME 13

The aspect ratio is a fineness ratio of the wing. The U-2, with a long, slender wing, has an AR of 19, whereas the X-15, with a stubby wing, has an AR of 1.5.

- - - - - - - - - - - - -

The aspect ratio is a ____________ratio.

---

fineness

FRAME 14

The AR of the T-28 (6.078) is very close to that of the T-34 (6.068)

- - - - - - - - - - - - -

The AR of the T-28 is (less than) (about the same as) that of the T-34.

---

about the same as

FRAME 15

The total weight of any aircraft is distributed over the entire wing. Wing loading is the weight supported by each square foot of the wing. Hence,

$$\text{(wing loading) W. L.} = \frac{\text{Gross weight}}{\text{Wing area (S)}}$$

- - - - - - - - - - - - -

An 8,000 lb. T-28 would have a wing loading of ________ p.s.f. (S=271 sq. ft.).

29.5

FRAME 16

The aspect ratio and the wing loading will determine the glide performance of an aircraft.

The T-34 will have a greater glide ratio than the T-28, because the wing loading is lower for the T-34 (16.3 p.s.f.) than the T-28, although both aircraft have a very close aspect ratio.

The U-2 will have a greater glide ratio than the T-28, because the aspect ratio is higher for the U-2 (19) than the T-28, although both aircraft have the same approximate wing loading (29 p.s.f.).

- - - - - - - - - - - - -

The ________________ and the wing loading will determine the glide performance of an aircraft.

---

aspect ratio

FRAME 17

Tapering the wing in planform improves its efficiency by improving the lift distribution. The T-28 wing has both leading - and trailing - edge taper, but it is not swept.

(a) Leading - edge taper is approximately 2 degreees.
(b) Trailing - edge taper is approximately 8 degrees.
(c) Root chord is 8.2 ft.
(d) Tip chord is 5.08 ft.

The wing is tapered in thickness towards the tip. This is done to improve the structural efficiency and to maintain constant thickness ratio. This type of wing is suited for a square wing tip and, if the edges are blended, will reduce the wing-tip vortices.

- - - - - - - - - - - - -

The advantage of tapering the wing in planform is to improve its __________ by improving the __________.

---

efficiency . . . lift distribution

FRAME 18

Tapering a wing's planform has implications for stall pattern development. Figure 6 shows that tapered wings are prone to stall first at the tip.

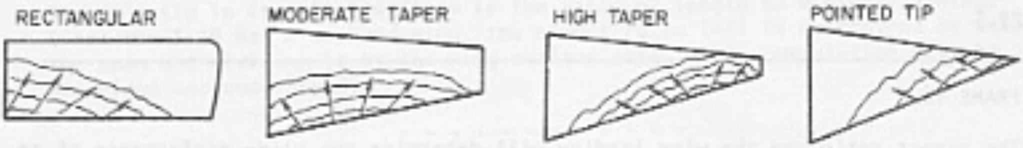
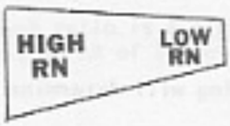


FIGURE 6a STALL PROGRESSION

Briefly, the reason this occurs is as follows. A prediction of where airflow separation will occur on a wing is possible through the use of a dimensionless parameter called Reynolds Number (RN). High RN's are associated (in part) with large chord surfaces, and small RN's are associated with small chord surfaces.

$$RN = Vx/v$$



where V = velocity
x = distance from leading edge
v = air viscosity

FIGURE 6b REYNOLDS NUMBER

All other factors being equal, stall will occur closer to the leading edge of a wing section with a low RN

\- - - - - - - - - - - - -

The T-28 wing has a lower RN at the tip because the wing is tapered in__________.

---

planform

FRAME 19

It is undesirable to have the tip stall first because the ailerons (for lateral control) are near the wing tips. Therefore, the T-28 wing has a +2° angle of incidence at the root and is geometrically twisted to a minus 1 at the tip. At the mean chord line, it is approximately zero. The 3° washout cause the root to stall first.

\- - - - - - - - - - - - - -

The T-28 wing is ____________________ twisted to cause the ____________ to stall first. A washout of __________________ degrees is created by geometric twist.

---

geometrically . . . root . . . 3
