Department of Transportation

FEDERAL AVIATION ADMINISTRATION

IFR PILOT EXAM-O-GRAM* NO. 18

"RATE OF TURN"

Many applicants who take FAA Instrument Pilot Written Examinations misinterpret the Turn and Slip Indicator and lack an understanding of the relationship between airspeed, angle of bank, and rate of turn. The purpose of this Exam-O-Gram is to remove some of this confusion.

Misinterpretation of the turn and slip indicator is caused by two major factors: (1) The marking and legend on the face of the instrument, and (2) misinterpretation of the "ball" (or slip/skid indicator). In general appearance, turn and slip instruments can be divided into two types: one having a center index only (see illustrations A and D of Figure 1), and the other having a center index and a two-needle-width deflection mark (doghouse) on either side (see illustrations B and C). A one-needle-width deflection on instruments having only the center index indicates a standard rate turn (3° per second). Instruments with doghouses may have different legends, e.g. "2-Min. Turn," "4-Min. Turn," "Turn and Bank;" regardless of the legend, if the instruments are properly calibrated, a one-needle-width deflection indicates a turn of 1.5° per second. A standard rate turn (3° per second) is indicated when the needle is aligned with the doghouse.

The turn needle indicates the "quantity" of the turn and is completely independent of the "ball." If the turn needle is properly calibrated, it shows the correct rate of turn <u>regardless</u> of the position of the ball. The ball indicates the "quality" of the turn. If the turn needle indicates a turn and the ball is not centered, and the pilot is using no pressure on the rudders, then the airplane is out of trim or rig. In this case, the pilot will have to use rudder pressure to center the ball and opposite aileron to keep the rate of turn constant. If the turn needle is centered and the ball is "out of center," the airplane is flying in a slip or wing low attitude. In airplanes without rudder trim, it is often necessary to hold rudder to center the ball; in this case the rudder is being used as a trimming device.

Assuming that the instruments in Figure 1 are properly calibrated and the airplane is properly trimmed for the speed and power setting, WHAT IS THE "RATE OF TURN" INDICATED BY EACH OF THE ILLUSTRATIONS, AND WHAT DOES THE BALL INDICATE?

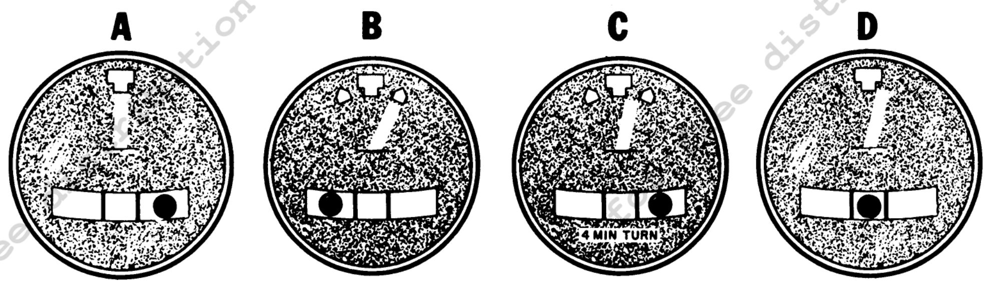

Figure 1

ANSWERS:

	Needle	Ball
A.	0° - no turn.	The ball indicates that the right wing is low. The pilot is holding left rudder.
B.	3° per second.	The ball indicates a skidding turn. If this occurs during the roll into a turn, the pilot is using too much right rudder; if the bank is already established, he is holding right rudder.
C.	1 1/2° per second.	The ball indicates a slipping turn. If the pilot is rolling into a turn, he is not using enough right rudder; if the bank is established, he is holding left rudder.
D.	3° per second.	The ball indicates a coordinated turn.

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Pilots should also understand the relationship of true airspeed and angle of bank to both rate of turn and radius of turn. Figure 2 shows three airplanes flying with the same bank at different airspeeds.

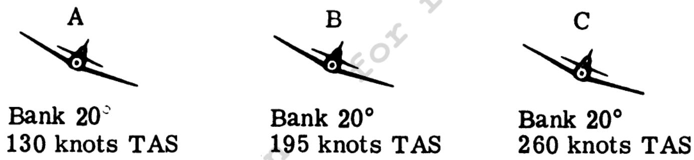

Figure 2

WHICH AIRPLANE HAS THE GREATEST RATE OF TURN?

ANSWER:

Airplane A, having the slowest airspeed and consequently the shortest radius of turn, has the greatest rate of turn.

Many people are misled into thinking that the fastest airplane would complete a 360° turn in the least time. This is not so! For example, one of our high speed jets flying at a true airspeed of 1,750 knots, and utilizing the 20° bank of Figure 2, would require approximately 26-1/2 minutes to complete a 360° turn. Contrast this with the 2 minutes it would take airplane A to complete a 360° turn with a bank of 20° and an airspeed of 130 knots.

Most pilots know that the radius of turn increases with an increase in airspeed, but do not know the ratio of this increase to the airspeed. If the radius of turn increased in the same ratio as the airspeed, then the rate of turn would remain constant. The actual radius of turn, however, varies as the square of the true airspeed. Therefore, since the speed of airplane C is twice that of airplane A, the radius of turn of airplane C will be 4 times that of airplane A: ($2^2=4$). Consequently, it would take airplane C twice as long to complete a 360° turn, since C will travel four times as far as A but is moving only twice as fast.