Low Level Aerobatics Display

As the RAAF's elite formation aerobatic display team, the Roulettes perform breathtaking displays, using only hand-eye coordination to fly at speeds of up to 590 kilometres per hour. The six Roulettes may experience up to 4.5G (or 4.5 times the normal force of gravity) during a display in their PC-9/A aircraft. When the Roulettes are not showcasing their skills, they teach qualified RAAF pilots to become flying instructors at RAAF Base East Sale in Victoria.

The plane being flown today is the RAAF's advanced trainer, the Pilatus PC-9/A.

Pilatus PC-9/A of No. 2FTS, Pearce, W.A.

Role:	Two-seat advanced trainer; forward air control and aerobatics.
Crew:	One or two pilots.
Engine:	Pratt and Whitney PT6A-62 turboprop (950 shaft horsepower, 708 kW).
Wingspan:	10.24 m.
Wing Area:	16.29 m^2.
Weight:	2250kg basic, 2710kg maximum.
Max. Speed:	595 kmh^{-1}.
Cruise Speed:	550 kmh^{-1}.
Rate of climb:	20.8 ms^{-1}.
g limits:	+ 7.0 g to -3.5 g

Source:
http://www.airforce.gov.au/Interact/Air_Force_Roulettes/?RAAF-rfHiMv85HKPcF1XWFcteALXKGiyJTpHL

Questions 1 and 2 relate to the information shown in the diagrams in Figure 1.

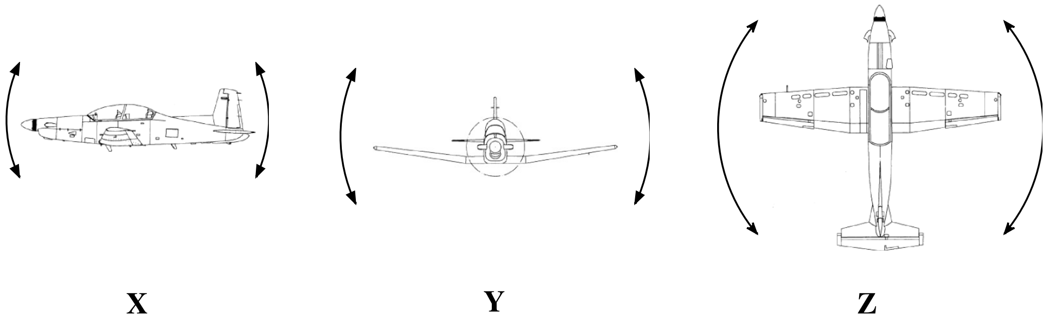

Figure 1

Question 1

For the airplane shown in Figure 1 which of the responses, **A – D**, correctly identifies the airplane's pitch, roll and yaw axes?

A. **X** = pitch axis, **Y** = roll axis, **Z** = yaw axis.

B. **Y** = pitch axis, **X** = roll axis, **Z** = yaw axis.

C. **Z** = pitch axis, **X** = yaw axis, **Y** = roll axis.

D. **X** = roll axis, **Z** = pitch axis, **Y** = yaw axis.

Question 2

Which one of the control surfaces, **A – D**, controls the airplane's motion about the ***yaw*** axis?

A. ailerons.

B. flaps.

C. rudder.

D. elevator.

Question 3

In terms of Newton's laws, an airplane's wing generates lift as it moves through the air because

A. the wing exerts an upward force on the air flowing over it and the air exerts an equal downward force.

B. the wing exerts a downward force on the air flowing over it and the air exerts an equal upward force.

C. the curvature of the wing forces air to travel over it at a faster speed than the air travelling under it.

D. air is deflected downward after colliding with the bottom of the wing forcing the wing upward.

Questions 4 to 6 relate to the following information.

At take off the Pilatus PC-9/A typically has a total mass of 2500 kg.

Starting from rest the PC-9/A needs 240 m of runway to achieve its take off speed of 43.9 ms^{-1} (158 kmh^{-1}).

Question 4

How long would it take for the PC-9/A to reach its take off speed of 43.9 ms^{-1}?

s

Question 5

What would be the magnitude of the PC-9/A's average acceleration during its take off run?

ms^{-2}

Question 6

How much work would be done by the PC-9/A's engine in accelerating the airplane to its take off speed of 43.9 ms^{-1}?

J

Questions 7 to 10 relate to the airfoil shown in Figure 2 below.

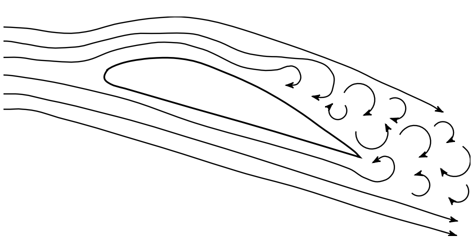

Figure 2

Questions 7

What causes the type of airflow over the top of the airfoil shown in Figure 2?

Questions 8

Describe what is happening to the airflow over the top of the airfoil shown in Figure 2.

Questions 9

Explain what happens to the lift generated by the airfoil when it is in this condition.

Questions 10

At what stage(s) during a flight could the airflow over the top of the airfoil shown in Figure 2 have dangerous consequences?

Questions 11 to 14 relate to the following information.

Figure 3 shows a PC-9/A shortly after it has taken off. It is flying with a steady speed of 54.0 ms^{-1} and gaining altitude at a constant rate of 18.0 ms^{-1}.

It has a total mass of 2500 kg and a wing area of 16.29 m^2.

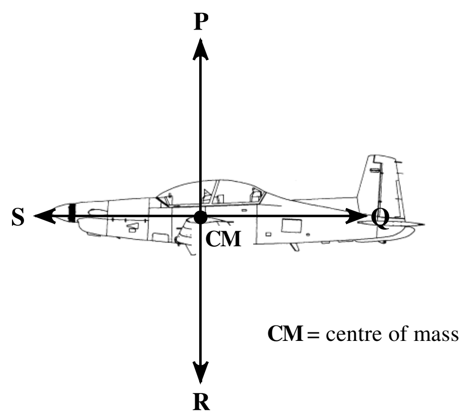

Figure 3

Question 11

On the diagram shown in Figure 3 the forces acting on the aeroplane are labelled **P**, **Q**, **R** and **S**. In the following table which of the choices, **A – D**, correctly matches the force to the appropriate letter.

	Lift	**Thrust**	**Weight**	**Drag**
A.	**S**	**P**	**R**	**Q**
B.	**P**	**S**	**Q**	**R**
C.	**S**	**P**	**Q**	**R**
D.	**P**	**S**	**R**	**Q**

☐

Question 12

For the situation described in Figure 3 the total lift force on the PC-9/A needs to be:

A. Lift = 2500 N. **B.** Lift = 25 kN. **C.** Lift > 2500 N. **D.** Lift > 25 kN.

Questions 13 and 14 relate to the following additional information.

The lift coefficient is a measure of the lifting capacity of a wing. It is a dimensionless number and is calculated by using the equation:

CL=L12ρv2A

Where *L* is the lift force, ρ is the air density, *v* is the airspeed, and *A* is the total wing area.

Question 13

Calculate the lift coefficient, C_L, of the PC-9/A's wing in this situation if the air density is 1.22 kg m^{-3}.

The graph in Figure 4 shows part of the graph of how the angle of attack of the PC-9/A's wing affects its lift coefficient.

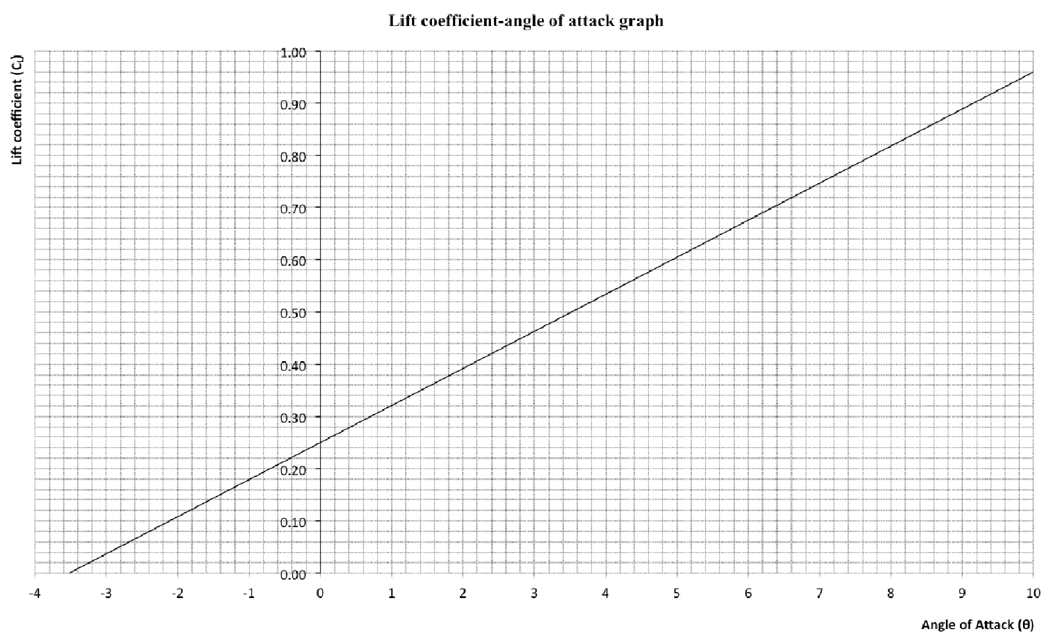

Figure 4

Question 14

At what angle of attack should the wing be set at, given the lift coefficient you calculated in Question 13?

1. velocity; acceleration $v = \Delta x/\Delta t$; $a = \Delta v/\Delta t$

2.	equations for constant acceleration	$x = ut + ½at^2$, $x = vt - ½at^2$, $x = ½ (u + v)t$ $v = u + at$, $v^2 = u^2 + 2ax$
3.	Newton's 2nd Law	$F = ma$
4.	Gravitational potential energy near the surface of the earth	$U_g = mgh$
5.	Kinetic Energy	$E_k = ½mv^2$
6.	Mechanical work	$W = Fx$
7.	Power	$P = W/\Delta t = \Delta E/\Delta t = Fv$
8.	Acceleration due to gravity	$g = 10\ ms^{-2}$