THE UNIVERSITY OF ADELAIDE
DEPARTMENT OF MECHANICAL ENGINEERING

EXAMINATION FOR THE DEGREE OF B.E.

9315: AEROSPACE ENGINEERING

JUNE 1999

TIME: 2 HOURS

[In addition, candidates are allowed ten minutes before the exam begins, to read the paper.]

[The use of notes, textbooks and calculating devices is permitted in the examination room.]

[Answer all questions.]

[All questions carry unequal marks].

[Appropriate engineering assumptions may be made for inadequate data].

QUESTION ONE

a) what was the biggest aircraft ever built; [1 mark]

b) what is currently the biggest aircraft; [1 mark]

c) sketch a wing that is linearly tapered and forward swept; [1 mark]

d) what vertical energy has to be absorbed by the landing gear, when the aircraft weighs 1,000,000 N and its descend speed is 3m/s; [2 mark]

e) describe the difference between the maximum rate of climb and maximum angle/gradient of climb; [2 mark]

f) describe or sketch a diagram of path of a plane with positive static and negative dynamic stability; [2 mark]

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QUESTION ONE CONTINUED.....

g) what does the equation $dM/d\alpha < 0$ mean in terms of longitudinal stability of an aircraft; [2 mark]

h) if the neutral point is in front of the centre of gravity of an aircraft, is the aircraft stable; [1 mark]

i) is a high wing aircraft more laterally stable than a low wing aircraft; [1 mark]

j) name four design features to reduce induced drag; [1 mark]

k) what is the maximum Mach number that the air flow can reach at the throat of a convergent-divergent nozzle; [1 mark]

l) through a shock wave do the pressure and density rise or fall; [1 mark]

m) does a shock wave reflect from a boundary layer; [1 mark]

n) what is the difference between a turbojet and a high-bypass ratio turbofan engine; [2 mark]

o) what engine drives a propeller in a turboprop aircraft; [1 mark]

p) name two different tail configurations for an helicopter; [1 mark]

q) why is the helicopter forward speed limited; [2 mark]

r) describe the advantage of a two stage rocket, compared with a single stage rocket; [2 mark]

s) what advantage has the linear aerospike engine to a rocket with a conventional engine and nozzle; [2 mark]

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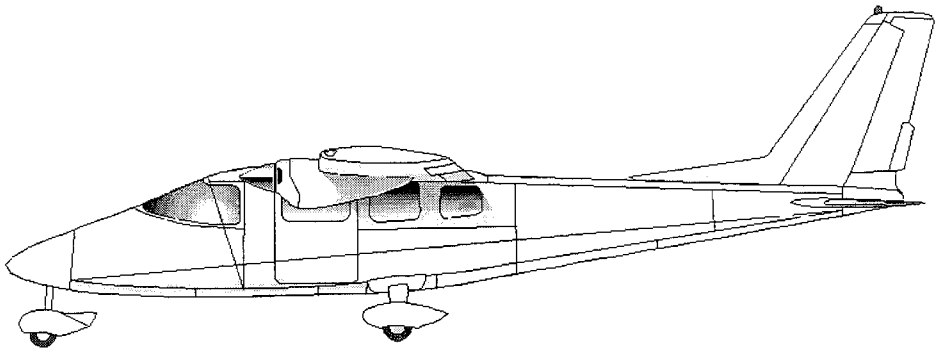
QUESTION TWO

A Partenavia P68 is a 7 seat, twin engine aircraft used by small airlines (see Figure). It has a wingspan of 39 ft 4.5 in and a constant chord of 1.55m. Its total landing distance is 488m with a landing speed of 90kt. Use for your calculations a weight of 2000 kg.



Partenavia
P-68 Victor

a) calculate the surface area of the wings [3 marks]

b) the aircraft is available with a turbocharged and non-turbocharged piston engine. Would you expect the two versions to have different service ceilings and why ? [4 marks]

c) at straight and level flight the aircraft cruises with 175kt at 4300 m. Calculate the downwash angle and hence the induced drag at that condition (take the surface area calculated in a) as total surface). [7 marks]

d) what is the approach angle of the aircraft during landing, if it has to clear only a 3 m obstacle; [7 marks]

e) the aircraft is also available with turboprop engines. Describe the difference to the piston engines in general and specifically in terms of performance (climb speeds, cruise speeds, landing distance etc.) [4 marks]

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QUESTION THREE

(a) An F-18 aircraft has mildly swept wings with sharp leading edges and is capable of flying at Mach 1.2. In contrast the wings of an F-111 have rounded leading edges, similar to a subsonic wing profile. An F-111 flying at Mach 1.2 sets its swing-wings in a highly swept or "delta" configuration.

Briefly discuss with the aid of diagrams the differences between the wing sweep and leading edge shapes of these two aircraft. Why does the "subsonic-like" profile of the F-111 function at supersonic speeds?

[8 marks]

(b) Briefly explain Whitcomb's area rule and at least one way in which it impacts on the design of transonic and supersonic aircraft.

[5 marks]

(c) A new design of aircraft is shown below in Figure 1. The aircraft flies at M = 2.0 at sea level (p_a = 100 kPa, T = 15°C, k = 1.4). The half-angle of the conical nose is 20 degrees.

(i) Will the bow shock wave impinge upon the wings? A plot of shock wave angle vs semivertex angle for various Mach numbers is given in Figure 1(b).

(ii) If the nose profile is altered to produce a very weak shock, will that shock impinge on the wings?

[12 marks]

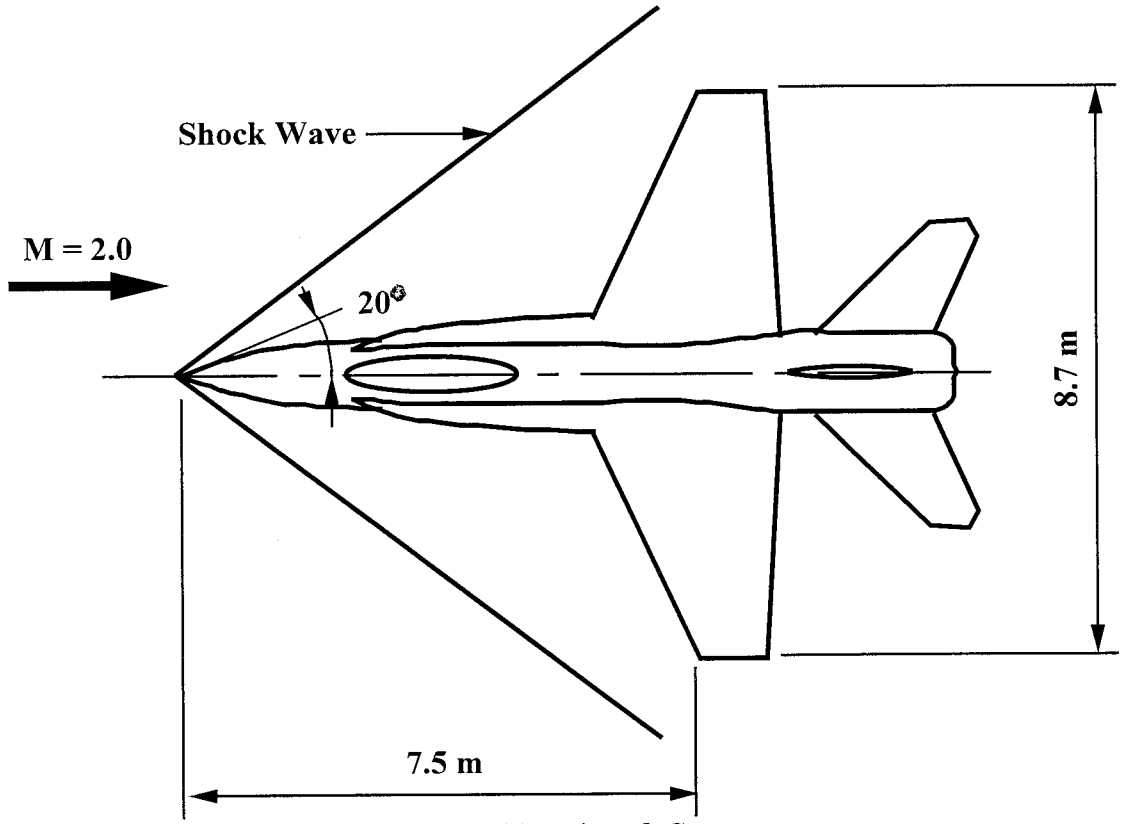

Figure 1 (a). Aircraft Geometry.

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QUESTION THREE CONTINUED.....

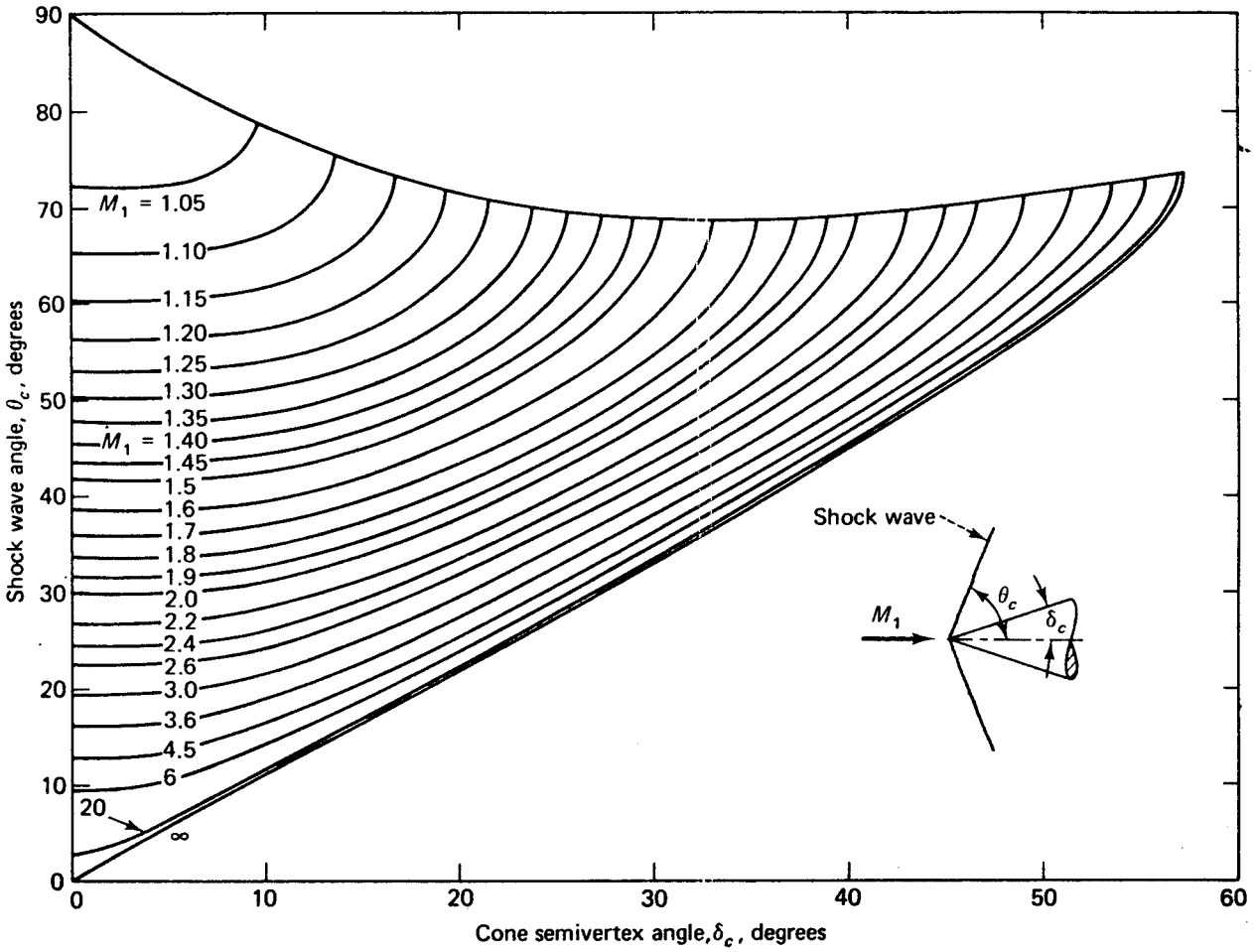

Figure 1 (b). Shock wave angle vs semivertex angle for various Mach numbers. This applies to 3-dimensional, conical shock waves..

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QUESTION FOUR

a) Describe the parameters in the Ziolkowski equation and under what conditions the equation applies. [6 marks]

A one stage rocket (with: payload mass + structural mass = 50kg), is positioned in space (0-g environment) with a velocity v_0=0. To reposition the rocket onto a re-entry trajectory it needs to be accelerated over a distance of 1 km to reach 10 times the speed of sound (c_{sound} = 340m/s). The propellant mass flow $\dot{m}$ and the effective exit velocity c_e of 2830m/s are constant during the repositioning and after the maneuvre all the propellant is used.

b) Calculate the mass of the rocket at the start. [4 marks]

c) Calculate the propellant mass flow rate $\dot{m}$. [7 marks]

d) If $\dot{m}$ is now double the result in b), what distance would the rocket travel to reach the same velocity (10 times the speed of sound). [3 marks]

e) If the rocket was in a 300 km orbit around the earth, what was the gravity force on the rocket ? [5 marks]

END OF EXAMINATION PAPER