



Examination Answer Books

12 Pages

Instructions to Candidates

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

1	Student Number	1810370
2	Title of Examination Paper	Scientific principles of OMS design
3	Module Code	ACDA 6008
4	Date and Time of Examination	5-5-2022 11:00
5	Examination Venue	FF001
6	Seat Number	
7	Number of Answer Books handed in	1 of 1

List the numbers of the questions you have attempted	Office Use
1	3
2	5
3	0
4	4
5	2.5
6	3.5
7	26
8	21
Total	65

Shape of warhead

- ① Velocity of warhead ✓ Density ✓ Mech properties of material ✓
 a. Angle of attack ✓ Nose cone thickness 1.5

- b. High Velocity of Detonation, but matched to the fragment. too much
 brisance may shatter certain fragments.
 Even VOD, ✓ 1.5

Point of initiation is important.

Thickness of case will have detrimental effect. ✓

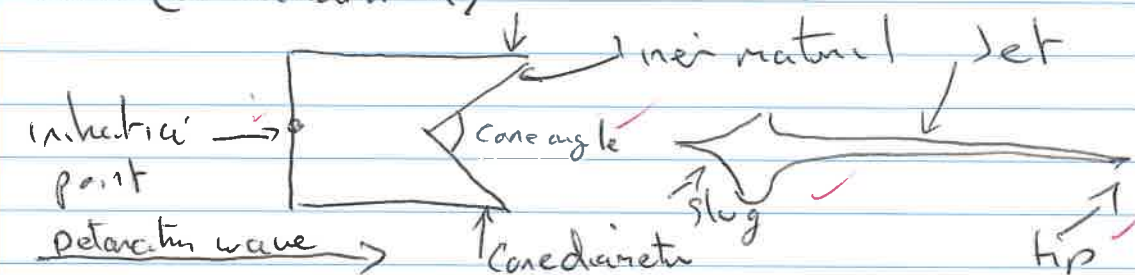
Will not work underwater or in earth as fragments are
 Attenuated quickly

Shape of fragment (drag) ^{aerodynamic}

~~If the case is too thick~~

Q1=3

- ② S&S is produced by a collapsing liner in a cone (or variation of)



Q2=5

The jet is up to 12 km/s. Requires stand off of between 3 and 8 cone diameters, dependant on material of explosive and of liner. Generally 5 CDs. Jet is 20% weight slug is 80% weight.

high density explosive is most suitable. HMX is good.

Tanks have explosive reactive armour. Non explosive reactive armour, or grid/lattice bars. ~~ER~~ All are used to prevent the jet from forming properly.

TO counteract the defences. Tandem shaped charges

Can be used. The precursors function is the ERA allowing the second charge to penetrate the tank's hull

Shaped charges can penetrate up to 6 cone diameter
~~maximum penetration depth~~

③

~~$$F = M \times A$$~~

~~$$350 = 40 \text{ kg} \times A$$~~

~~$$\therefore \frac{350}{40} = 8.7 \text{ m/s}^2$$~~

$$P = \frac{F}{A}$$

$$F = A \times P$$

$$\pi r^2 \times 350 \times 10^6 = F$$

$$F = 6.6 \times 10^6 \text{ N}$$

$$0.5 \pi r^2 = A$$

$$A = \frac{6.6 \times 10^6}{16} = 412500 \text{ m}^2$$

Q3
= 0

- ④ a. Certainly initiated blast wave will be completely omnidirectional. The wave will be equal in all directions at all distances as it expands over time. Isotropic
- b. The wave will be non-isotropic and the wave will move in the direction of the detonation wave, material used, any casing + thickness, reflected waves inside the charge + coned edge
- c. Aluminium particles react with the detonation products of the material. They can double the energy of the warhead. The peak overpressure may be lower, but allows giving a longer pressure pulse. It adds heat to the detonation. Allows for bigger bubble to be made but last longer

Q4
= 4

⑤

Weakening of structure from blast waves interact with the structure

Blast + Dynamic Loading + Deformation Loading

Diffract waves as they pass around corners

Q5
= 2.5

Direct blast - collapsing shock
- weakening structure ✓
- deforming the structure ✓

indirect damage - from the debris system, Case example bricks and chairs being thrown around

initial shock wave can weaken structure

Peak overpressure
+ve + πv phase

dynamic pressure



- ⑥ a. The length of time the propellant remains in serviceable condition and safe. Still delivers projectile to original spec
- i.e. • Correct mech properties
• Correct burn rate ✓
- Specification

- b. Temperature of storage (or usage if stored in field) (not tried) Q6
Correct type/amount of stabilizer
If moved from Hot to Cold places ✓

Initial composition

Moisture ingress, contamination ✓

- ⑦ a. for an aircraft 2 mechanisms for attack. Blast and fragmentation. Blast diminishes with altitude, here for contact or more appropriate internal blast are useful. This means that the system missile must be very accurate to hit/penetrate the target.

example?

Fragmentation warheads are much better. They do not have to hit the target. They must function close to the target. The distance they need to be within is the damage volume. In this area if the target is in the damage volume of the warhead, then it is predicted that the warhead will be lethal to the target. ✓

The fragments can be of various varieties. Controlled, natural. Natural just allows the explosion to break up the case. This may lead to wasted energy of the explosion breaking the case and not distributing fragments properly.

Controlled may be performed, with case material where the case is "cut" to create. This is when the fragments are made separately and added to the explosive during manufacture. This can be very expensive, but leads to the fragments being exactly as required.

Forged fragments can be where ridges in the explosive are a liner around the explosive force the case to be broken in a certain pattern, creating the fragments.

CONTINUOUS

Rod fragments are rods designed around the case. Continuous or expanding rod produces a large ring of metal (steel) which will "chop" or "slice" sections of the aircraft such as the wing, fuselage or tail. Other rod warheads are not designed to expand. Instead the rods flail out which create large damage to target area.

Size and density of fragment is important. The correct size/density will give the best damage volume. To optimise the damage window beam width of fragments is considered. This is controlled by type of explosive used.

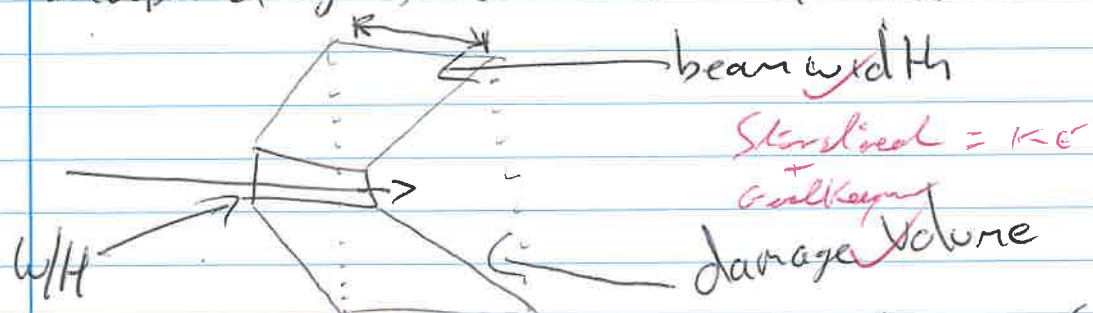
The point of detonation of the warhead and the shape, rear initiated warhead will have a narrow beam with but further forward throw of fragments. Front initiat will not throw as far forward, but will give a wider beam width, however may not have the same radial distance.

Should consider that fragment warhead may be ineffective as the aircraft will only be in one place in the damage volume. However a large damage volume will allow more chance of target neutralization.

Typical warhead could be 5kg - 50kg dependent on delivery system.

Systems in use may be, rapier, amraam, ASRAAM, METEOR, SEA DART, SEA VIPER, SEAWOLF

Helicopters fly low altitud. therefore blast cube used, or shaped charge. To destroy the target. they move slower. RPG will work, Starshock will work. W/H need be a couple of kg. Starshock has a W/H less than 1kg



- b. ~~First~~ A submarine is underwater. here blast ~~can~~ be used. however, ~~that~~ the direct blast means that the warhead must be in contact, or very close as the shock wave will diminish quickly underwater. The sonic velocity underwater is 1500m/s, 5 times the 300m/s in air. Sea mines may be usable in this case with 400kg of explosive. This will damage the hull and damage systems as the sub shock passes through the hull. Blast will reflect off the seabed and surface.

The bubble pulse can be used on a submarine. But is not as

effective unless the sub is near the surface in "shallower" water. The bubble can oscillate up to 10 times each time rising in the water, and each pulse stresses the hull of the submarine, weakening its structure.

$$\text{bubble radius} = k_{\text{exp}} \sqrt{\frac{w}{h+10}}$$

$k = \text{explosive constant}$
 $h = \text{depth (m)}$
 $w = \text{explosive mass}$

The best for a submarine is shaped charge. Delivered by torpedo or autonomous mine. The charge only needs to be ~30kg of explosive with a copper or copper-alloy liner. A tuba shape cone is better than flat cone allowing greater penetration. HMX is a suitable explosive to give maximum power energy to form the cone. The hole punched in the hull of the sub will be ~fist sized and the penetration at the distance of the jet can also breach a 2nd hull of 2 hulled warships. Start off need around 5 CDs in use are Stingray, Eutop (Mug0), Mk46, ~~M46~~ Mk54. The best target area is where the conning tower meets the main hull as this is the weakest point on the boat.

In both Aircraft and Submarine world, the best warhead would be a nuclear warhead as it will have the largest damage volume / blast radius both in air and under water. This has the advantage that it does not have to be specially accurate. Current warheads include Trident, W88, W76, B61

- ⑧ Gun propellants come as
- Single based
 - Double based
 - Triple based
 - High energy
 - Composite

Shape of grain determines how the grain will burn

Piobert and Vieille theories help explain.

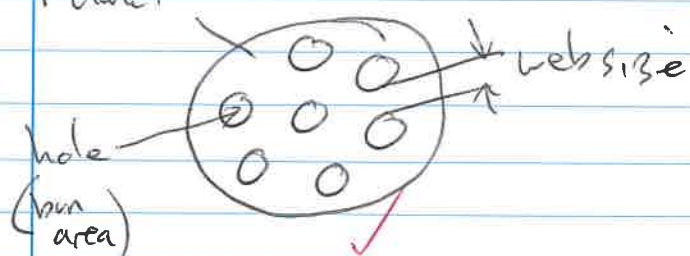
Piobert - the grain will burn on the surface and ingress toward the center axially along the normal plane

Vieille says $r = \beta P^\alpha$

meaning that the rate of the burn is determined by pressure and a burn constant and a constant for the specific material.

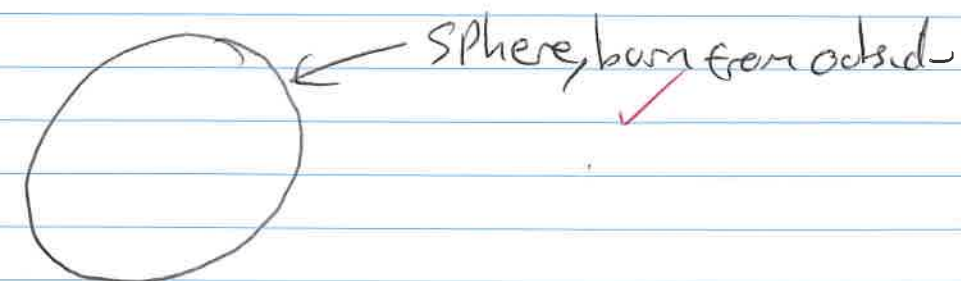


Progressive burn slow at the start but fast to the end



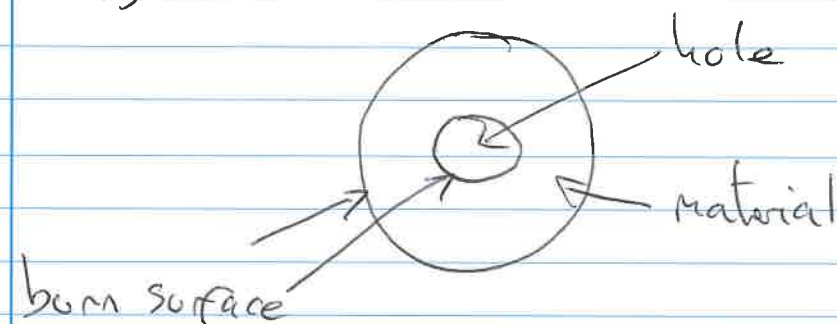
As the burn area gets wider, there is larger surface area for burn therefore will burn faster.

Regression starts with a fast burn but slow down as surface area shrinks



as the surface burns away, the surface area gets smaller.

Neutral have a steady burn that is more constant throughout.



As the inner surface burns out, it gets larger, but as the outer surface burns in, it gets smaller, thus keeping the overall surface area the same

Single based, just NC + binder NC about 13.5~ has a lower energy of 950-1000 J/g suitable for all types of propellant

Double based, NC + Nitroglycerine (20% NG at most to keep temperature down), higher energy of 1250 J/g suitable for SAA and SMA

Triple based, NC + NG + NQ (nitroguanidine), energy in the region of 1000-1250 J/g.

NQ lower flame temp, helps avoid muzzle flash but can add to wear of the barrel.

Suitable for Naval 4.5" gun / tank and Artillery

Higher energy contain RDX, create high velocity such as KE rounds. Must be under 700 m/s

Q8a
=7

High energy (RDX containing) propellants may be more susceptible to accidental initiation by impact, and the consequences could be more diverse.

Question No.

b. Next generation of gun propellants will be:

green (less harmful to environment) ✓

Safe to handle ✓

Safe to store/move (Capable of being classed as IM insensitiv Materials) ✓

Long shelf life, Nitrocellulose degrades and lowers shelf life ✓

Multipurpose, suitable for all environments ✓

Possibly Caseless, or use consuming case
Liquid may be suitable ✓

c. Conventional NC must have a stabiliser added, such as carbonite (ethyl centralite). As NC degrades with time it "gives off" NO_x . This NO_x can create free radicals in the propellant which can lead to heat being produced. This will eventually lead to possible self-ignition. The stabiliser is added to " mop up " the free radicals preventing the heat being produced. However it does not stop the change in mechanical properties of the NC which have a specification to meet.

NC degradation can be estimated using Arrhenius equation. Heat of storage has a detrimental effect on the propellant, ~~speed~~ shortening its shelf life.

NC is also a smoke producing propellant. This ~~can~~ can give away the position to the enemy.

Liquid propellants are being produced. Although difficult to use (currently) the change in gun structure, i.e. a liquid will leak out of a standard breech. They have advantages

Examiner Only

Question No.

In Heavy they are less susceptible to accidental ignition.
Cheaper to produce. ✓
Easier to store in large quantities ✓
Easier to transport
Can be stored/transported in bulk) -
High energy per unit mass ✓
~~trans~~

In Heavy they are also tunable, where you can break the amount necessary to exactly what you want.
Conventionally, NC has variant bag charges, but they are stepped, where liquid would be "fluid" progression.

Caseless propellants are being developed which where the structure of the case is the propellant itself. Here there is no brass, so it's being called "greener" as no brass used. They may however be brittle and susceptible to damage if mishandled ✓

Nitrocellulose is currently not manufactured in the correct grade in the UK. Therefore, for all propellants, the UK must source its NC from abroad.

LOVA is low vulnerability Ammunition where composite propellants have additives in them to reduce the chance of accidental ignition ✓

Q8b
=2

Examiner Only

Q8c
=12

Q8
Total
=24

Arholwr yn unig

Rhif y Cwestiwn

Arholwr yn unig

Rhif y Cwestiwn