



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	1810364
2	Title of Examination Paper	Scientific Principles
3	Module Code	ACDA 6008
4	Date and Time of Examination	05/05/22 11:00
5	Examination Venue	Library FF001
6	Seat Number	
7	Number of Answer Books handed in	1

List the numbers of the questions you have attempted	Office Use
1	3
2	4
3	
4	6
5	2
6	4
7	22
8	17
Total	56

①

The kinetic energy density of the warhead affects penetration. This is also affected by the geometry of the warhead as well as the case material.

To maximise the velocity of fragments the following is important:

Type of explosive used

Case material

Thickness of case

Angle of attack

Velocity of missile

ie dynamic velocity $W = \sqrt{V_0^2 + V_m^2}$

& Gurney Constant

Mott determined that small fragments occur as a result of brisant explosive, limited ductility of the material. Large fragments a low energy explosive and ductile material.

The point of initiation also affects the performance of fragment as affects the beam width.

Q1
= 3

②

Shaped charge jet is a misnomer as acts more as a liquid plastic. The liner of the warhead collapses on initiation and forms a jet acting as a hydrodynamic penetrator.

SCJ travel $> 1000\text{ms}^{-1}$ and typical have a cone diameter of between 3 and 8 for maximum performance.

It is ~80% slug, 20% jet.



It is used to attack the front of the tank as is not affected by the oblique angle.

A tank can defend using explosive reactive armour (ERA) or nonexplosive reactive armour (NERA) which act as a sandwich or sort, a plate a gap, then another plate. This is designed to reduce the SCJ effect by greatly reducing the KED.

Some munitions consist of a second SC so the first one takes out the defense and the second one affects the target.

②2
4

③

Force = Mass $\times$ acceleration

$$\text{Acceleration} = \frac{\text{Force}}{\text{mass}}$$

$$40 \times 0.155 = 6.2 \text{ kg}$$

$$\text{Mass} = \frac{\text{Force}}{\text{acceleration}}$$

$$1) \quad 350 = 40 \times a$$

$$\therefore a = \frac{350}{40}$$

$$= 8.75 \text{ ms}^{-2}$$

$$2) \quad \text{Mass} = \frac{600}{8.75}$$

$$= 68.57 \text{ kg}$$

$$40 \times 0.135 = 5.4 \text{ kg}$$

Q3
= 0

④

The blast wave from a centrally initiated spherical charge will be omni-directional and will waste a lot of the blast energy.

Other factors that affect the blast wave are air density, case material and thickness, explosive type used and location of initiation i.e. high altitude.

Adding aluminium to explosives - increases the total energy

- increase duration / positive impulse of explosion
- reach slower than explosive, wait for initial shockwave to pass
- may double the energy output

Q4
=3

⑤

Diffraction loading - the blast travels round corners with the structure causing maximum internal damage.

Dynamic loading - detonation products are carried by the air

Q5
=2

- ⑥ The ballistic life of a gun propellant is how long the propellant can be stored/used safely without degradation of the composite parts. It can be increased by adding stabilisers to the propellant mix. Other additives can be added to the propellant to help with this.

Factors that affect the ballistic life are - migration of parts to the surface ✓
 - on degradation the production of nitrogen oxides. ✓
 - storage temperatures affect the rate of degradation. ✓

Can be prolonged using plasticisers, surface moderators, stabilisers and coolants. ✓

⑦a)

An aircraft's greatest enemy is gravity, by causing damage to a wing, fuel tank, pilot, engine etc the plane aircraft will likely go down. Due to the nature of aircraft they need to be made of relatively lightweight material in order to fly.

The two main ~~workhead~~ effects are blast and fragmentation. Because at higher altitudes air density is less, blast has very little effect as loses a lot of energy to the atmosphere, equally at the velocities of travel the timing to detonation would have to be dead on.

As such a fragmentation warhead is the best means to defeat an aircraft. The fragments travel at a greater velocity than the munition or the aircraft, equally you would only need them to have the KED of $\sim 250 \text{ J m}^{-2}$, which is the equivalent of 30mm steel plate, to take out/damage the target.

Going back to Mott's determination, the warhead would have to be relatively lightweight, ~~therefore~~ you would probably want large fragments so a ductile material with a thickness between $0.008 \text{ m} - 0.015 \text{ m}$ using either an RDX mix or a HMX mix would be sufficient. Having a thicker case will decrease fragment aerial density but increase the size. It is a trade off, though as this affects velocity as determined by Gurney.

$$V_0 = \sqrt{2E \left(\frac{M}{C} + \frac{1}{2} \right)^{-1/2}}$$

You would want a relatively good beam width which would be dependent on the point of initiation, so either rear initiation or central initiation. The case material and thickness will also affect overall performance of the warhead as will affect the equivalent bare charge which highlights how much explosive energy is used/wasted disrupting the case.

$$W_b = 1.17 \left(\frac{1+M_r}{M_{\text{max}}(1-M_c)} \right) C$$

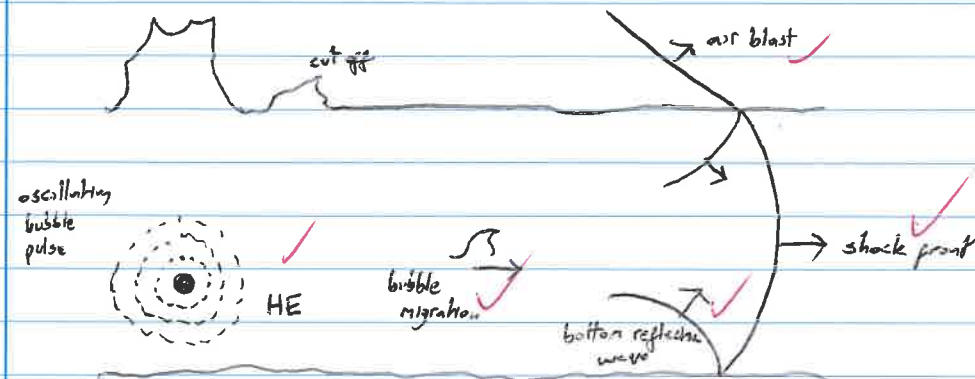
Another method for disabling aircraft is through use of a continuous long rod penetrator. The rods are going together at one end, on firing the rods expand forming a circle which results in significant laceration damage to the aircraft.

Would have been more marks if kept (is question:

Typ of LMS - blast (internal), frag (external)
 K&T type
 w/n sizes, examples, etc

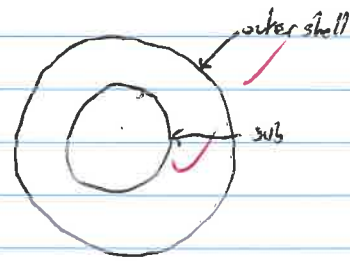
(7)b

A submarine is a subsurface sea target which can be at variable depths. The greatest lethal effect is blast within water; this is because water is less compressible than air, so the blast waves are amplified.



The above sketch roughly shows the effect of an underwater blast, a target would end up being hit by multiple waves and/or an underwater mach stem equivalent.

Ideal munitions to defeat these targets are torpedoes, mines and depth charges. Most of which contain a large amount of explosives. They are designed to initiate beneath the target so the blast essentially breaks the back of the sub. However as submarine technology has developed to cope with greater depths, some which have several metre thick shells filled with water to withstand the pressures, this has resulted in blast warheads/munition being less effective. Whilst it may not be as lethal it can still cause weaknesses in the structural integrity of the sub, forcing it to surface.



A method to overcome this is by using a SCJ warhead which pierces the submarine resulting in loss of pressure. This could be done have multiple SC's in the munition or a SC then

a blast effect to get maximum internal damage.

Examples? Sizes?

(8)a

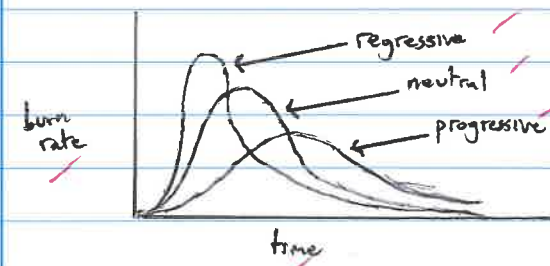
Single base propellant - nitrocellulose (has a negative oxygen balance)
- used in small arms to artillery i.e. pistols and mortars
- has a Q value between ~3100 and 3700

Double base propellant - nitrocellulose + nitroglycerine
- used in small arms i.e. sub machine guns
- has a Q value between ~3600 - 5200 (required for quicker rate of fire)

Triple base propellant - nitrocellulose + nitroglycerine + nitroguanidine
- used in large calibre guns i.e. naval and tanks
- has a Q value between ~3200 and 3700

Multibase propellant - nitrocellulose + nitroglycerine + nitroguanidine and/or RDX
- used for tanks only

Regressive grain designs i.e. a sphere, reduces in surface area when burning
Progressive grain designs i.e. a cylinder with multiple holes, increases in surface area when burning
Neutral grain designs cover everything in between.



Regressive has a short burn rate
Progressive has a long burn rate.

- b) Desirable properties of next generation gun propellant are:-
- long shelf life ✓
 - cost effective ✓
 - non hazardous (i.e. environment) ✓
 - non toxic (personal) ✓
 - safe to store and handle ✓
 - IM ✓
 - caseless ✓
 - LOVA ✓

⑧c)

Conventional nitrocellulose gun based propellant have a variety of issues. They often degrade releasing nitrogen oxides which can result in autoignition. They have to be cased which causes degradation to the weapon, equally because they tend to be negative oxygen balance this results in excess energy being transfer in other means such as smoke, heat and muzzle flash. These propellant also tend to when degrading, impurities move within the compound or to the surface resulting in changes in performance and ballistic properties.

To some extent these have been addressed through the addition of additives to the compounds such as - stabilisers (increase shelf life)

- plasticisers (ease of forming)
- de-coppering agents (removes ^{copper} case debris from barrel)
- anti-wear agent (removes debris from barrel)
- surface moderation (prevents movement of impurities / helps maintain performance)
- surface lubrication (ease of filling cartridge)
- coolants (keeps cooler reducing chance of autoignition)
- anti-flash

Development into things like LOVA (low velocity ammunition) and caseless ammunition negate some of these shortcomings.

More insensitive munition compounds are being developed to maximise safety and for personnel, equipment and environment.

Liquid propellant are still relatively new but development is ongoing. These take away the need for a case as they are mixed separate to the projectile. They typically consist of fuel, oxidiser and water. Liquid propellant come into two categories monopropellant and bipropellants. They are currently only really used in rockets and other equivalents that require a lot of energy.

8c

8

28c

=8

Total = 17