



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	1810440
2	Title of Examination Paper	SCIENTIFIC PRINCIPLES OF ONE DESIGN
3	Module Code	ACDA 6008
4	Date and Time of Examination	5/05/2022
5	Examination Venue	FF001
6	Seat Number	
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
1	3
2	4
3	0
4	6
5	2
6	4
7	22
8	17
Total	58

- ① (a) Penetration on a target relies on:
- Mass of warhead
 - Density of warhead?
 - Velocity of warhead ✓
 - Material of warhead (hardness of case or long rod penetrator) ✓
 - Thickness of target armour
 - Angle of target armour / angle of attack ✓

Q1
=3

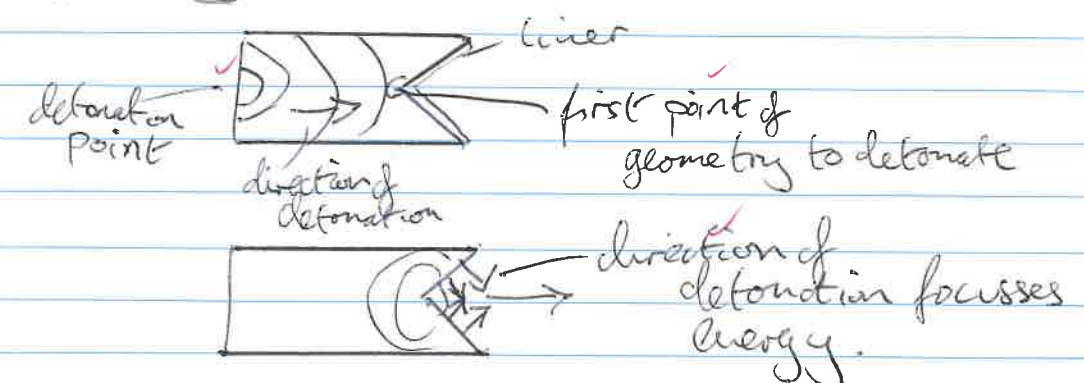
- ⑥ Characteristics to maximise fragment velocity:
- Sufficient energy to burst the case ✓
 - High velocity of detonation (proportional to density of HE fill) ✓

Negative factors on performance:

Case material properties (softer metals will not form effective fragments as they will disintegrate under pressure. Harder metals are better for larger fragments)

Thickness of case (Too thin and case will rupture rather than fragment, too thick & case will not fragment. Can be mitigated by strategic weakening of case by scoring or chemical etching to design fragment shape).

- ② Shaped charges work by focussing the blast using charge geometry.



- ② The liner turns superplastic under the forces generated by the detonation and exhibits hydrodynamic behaviour. The material of the liner is translated along the jet formed by the directed energy at speeds of 8-12 km/s and penetrates the armour. 20% of the liner material is translated with the jet and the remaining material (the slug) follows behind through the pathway left by the jet and defeats the armour.

Q2
= 4

The tank can defend itself using ERA to disrupt the jet, angled armour to affect the effective jet formation, or spaced armour to effectively disrupt the jet or change the standoff.

A warhead can defeat these principally by having two SC components, the first to defeat the ERA and the second to penetrate.

③

$$\text{Mass} = 40 \text{ kg}$$

$$F = 350 \text{ MPa} (350 \times 10^6)$$

$$F = ma$$

$$a = \frac{F}{m}$$

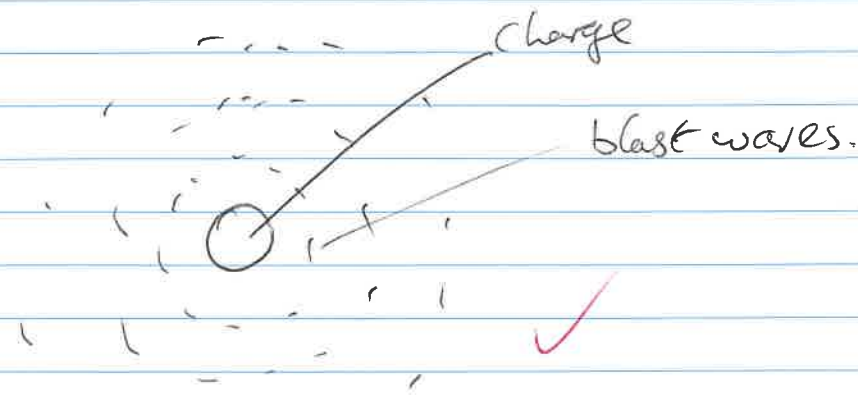
$$a = \frac{350 \times 10^6}{40}$$

$$= 8750000 \text{ ms}^{-2}$$

=

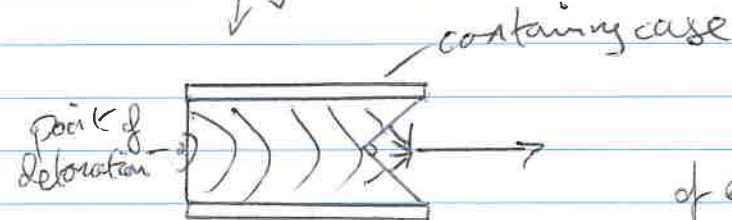
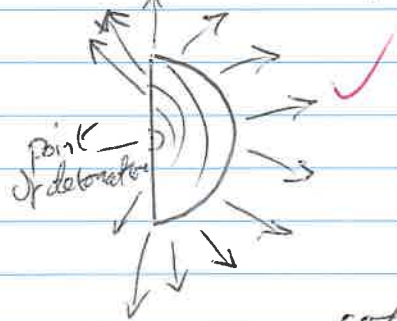
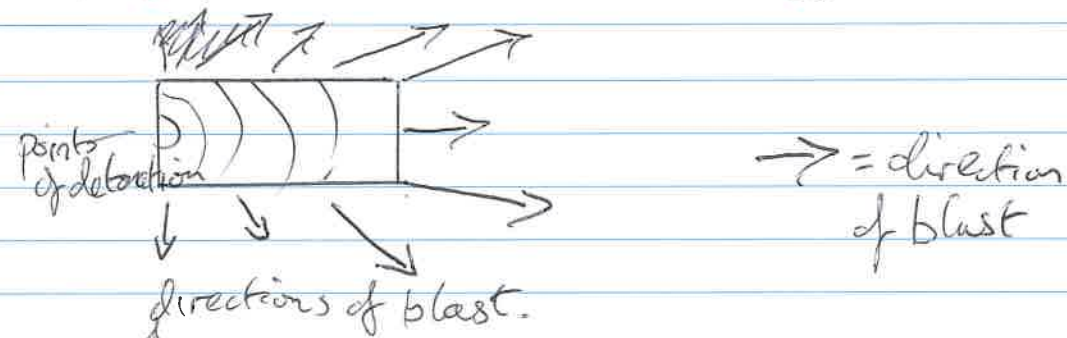
Q3
= 0

(4) (a)



Charge is initiated and energy is translated in all directions.

- (b) Direction and magnitude are different depending on point of detonation and charge geometry.



Case directs flow of energy towards the geometry which further focuses directs blast. The case will fail eventually but not before the majority of energy has been directed

(4) (c)

Adding aluminium to an underwater explosive improves the performance by reacting with the HE products. The reaction increases the overall energy of the blast and causes the impulse to last longer. Whilst the peak overpressure may be less, due to it taking longer for it to decay, the overall energy exerted is higher.

- (5) ^{Blast} Shock. The initial force exerted by the detonation wave upon the building. Can cause ^{or failure} weakening of structure. Dynamic pressure. A transient wind follows the detonation wave carrying other detonation products.

DIFFRACTION LOADING

- (6) Ballistic life of gun propellant is the time a propellant can be stored at a known temperature before it starts to undergo autocatalytic decomposition. This is generally a result of the breakdown or migration of the stabiliser within the propellant.

Factors that influence ballistic life:

Storage temperature (higher causes quicker degradation)

Storage conditions (moisture ingress also speeds up time until decomp)

Amount of stabiliser
N₂ content of NC

Q5 = 2

Q6 = 4

- ⑦ (a) ~~Missile~~ ^{damage} Attack for aircraft. Blast in air drops off dramatically with distance from target so whilst a warhead will be very effective if it detonates inside the craft, with the speed of modern craft, this is unlikely. A better method for disabling aircraft is to use kinetic energy of fragmenting warheads. As a large quantity of energy of a blast warhead is wasted (omnidirectional energy burst), it is easier to direct a large quantity of fragments into a much smaller area using a smaller quantity of explosives. Most modern firing systems that attack aircraft are designed to miss the craft itself and throw out a cloud of fragments to target any or all the main ~~off~~ ^{vulnerable} points in an aircraft (pilot, engine, wings), any which being disabled will render the platform disabled or destroyed. Another type of warhead is continuous rod warheads, which are designed to expand into a circle of continuous metal which acts as a 'buzz saw' effect to separate important parts of the aircraft.

As these types of warheads require less energy to produce effective results, smaller munitions may be used. This is exceptionally important to smaller single engine attack aircraft where weight is a priority. This can mean the difference of ~5kg frag warhead or ~50kg blast warhead.

usually small (black hole) Internal blast?

- ⑧ Attack of a submarine. Conversely to air blast, underwater blast is much more effective, whilst frag warheads are almost completely ineffective due to the drag exerted by water. Water is only slightly compressible, and the sonic velocity is ~~at~~ ^{at} 1500 m/s against 330 m/s in air. This means blast translates much more in water. ~~When~~ ^{oscillating} A blast effect in water causes a bubble pulse where the pressure of the blast forces a bubble to form. This bubble reaches a certain

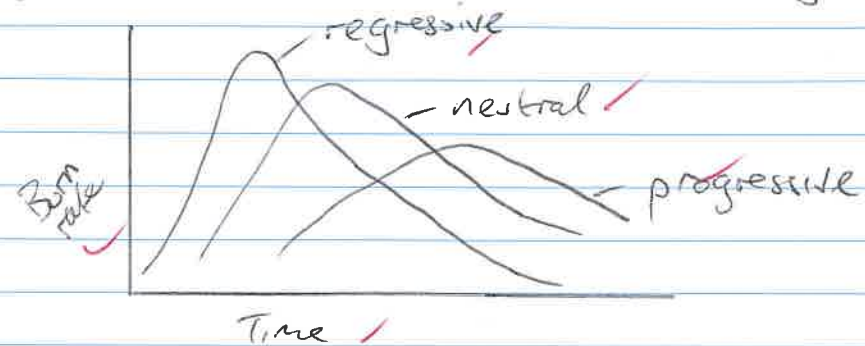
Size (dependant on HE fill and amount) then collapses on itself. Once it reaches a certain critical size, the pressure pushes the bubble outwards again, expanding and contracting as it travels towards a rigid body. This multiple expansion and contraction process can cause multiple interactions with a submarine's hull, weakening + causing failure. Due to submarines having a second, inner hull to mitigate against this, another method to defeat them would be to use a shaped charge at close range to perforate the hull. Either method can cause spalling on the interior of the vessel allowing for secondary fragmentation to injure and damage vital systems to disable or destroy the target.

- ⑧ (a) Gun propellants can be either Single Base (NC, stabiliser and plasticiser) or Double Base (NC, ^{13.15} N_2 , NO_2 , stabiliser and plasticiser). Double Base (DB) is used more often with short barrel pistols or SMG's as it has a faster burn rate and reaches full burn a lot sooner in the barrel. However this increased burn rate means it is not as suitable for longer barrelled guns as this increases barrel erosion.

Propellant grain geometry is important for burn rate as Piobert's law states that a propellant burns evenly across its surface area in layers normal to its surface. This gives a direct relationship between geometry and burn rate (ie if the grain was a sphere, the surface area would reduce with burning, but if a ~~hollow~~ ^{hollow} geometry was such that burning layers off increases the surface area, such as that of a cylinder, the burn rate would increase.)



This gives rise to three types of burn rate: progressive, neutral and regressive, where the burn rate increases, stays the same or decreases respectively.



⑤ Next generation gun propellants are being designed for:

- Safety (less vulnerable to credible threats) ✓
- Higher muzzle velocity ✓
- Less environmental effects (toxicity) ✓
- Higher specific impulse ✓
- Cheap to manufacture ✓
- Safer to store (increase ballistic life) ✓

8b = 3

⑥ Nitrocellulose in itself is a flammable solid, and tends to break down as its NO groups (esters) fall off as they are only weakly bonded. This is why there is a ballistic life on propellants of this kind. Reaction occurs naturally as age causes migration and breakdown of the stabilisers within these propellants which affects the safety, ballistic properties and mechanical properties of the munitions. Efforts as we are trying to move away from these ~~issues~~ materials and their associated issues, research into other avenues is happening. ~~Research~~ Liquid propellants are being researched as a viable alternative however this will require a much more complicated gun design to prevent leakage, inadvertent mixing of hypergolic liquids, correct quantity of

8c = 8

liquids administered, etc. Depending on storage requirements these might also be more vulnerable during transport, handling in theater, or ~~storage~~ long term storage.

Conventional gun propellants (NC base) also have an issue with high temperatures and by-products contributing to barrel erosion. Alternatives to this could result in lower ignition temperatures able to improve the life of the actual gun.

Lova, LPG, CCC, CMPC + LTC
→ New Novel solution

8 TOTAL
= 17
(6+3+8)