



Complete, fold and seal
(see note 2 below)

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FORENAME(S): STUART

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	1809912
2	Title of Examination Paper	SCIENTIFIC PRINCIPLES OF ONE DESIGN
3	Module Code	ACDA 6008
4	Date and Time of Examination	5/5/2022 1150.
5	Examination Venue	FF 001
6	Seat Number	
7	Number of Answer Books handed in	1

List the numbers of the questions you have attempted	Office Use
1	4
2	4
3	0.5
4	4
5	4
6	3
7	26
8	16.5
Total	62%

① Penetration can be achieved by fragmentation or direct impact. Fragment size and velocity need to be above set parameters depending on target. The density of the explosive composition and its velocity of detonation will affect the velocity of fragments. Higher density and higher VOD results in higher velocity fragments. Fragmentation can be affected by case thickness and case material and also the size of explosive charge.

Q1=4

② A Shaped charge jet consists of a ^{shaped} cone, metallic (usually) liner, backed by explosives that is ~~detonated~~ initiated at the rear. When initiated the shock collapses ~~the~~ and inverts the cone liner. The liner behaves hydrodynamically, like a liquid, but is in fact a 'super-plastic'. The liner forms a jet, where the tip reaches velocities up to 12 km/s . 80% of the SCJ makes up the slug that follows the jet at a lower velocity ($\sim 2000 \text{ m/s}$). Stand-off of approx. 4-6 ~~and~~ cone diameters allows the jet to form for effective perforation. ~~Armoured vehicles~~ can defeat this effect using explosive reactive armour, or spaced armour in order to disrupt the forming jet. One method to overcome this, is a tandem shaped charge warhead. ~~Many modern warheads are designed to be delivered 'Top Attack' where there is less armour to penetrate.~~

Q2=4

③ $F = \frac{P}{A} = \frac{350 \times 10^6}{\pi \times 0.0675^2} = \frac{350 \times 10^6}{0.0143138} = 2.44519 \times 10^{10} \text{ N}$

$a = \frac{F}{m} = \frac{2.445 \times 10^{10}}{40} = 611298187.8 \text{ m/s}^2$

Q3=0.5

- ④ A centrally initiated spherical charge causes an omni-directional blast wave to form.

The ^{position} ~~point~~ of initiation (rear, front, central) will affect the blast wave of explosive charges.

Adding aluminium to an underwater explosive increases the energy. The reaction is slower during the positive phase, which increases the impulse. Peak overpressure may reduce but performance increases.

- ⑤ Blast Loading - Initial shockwave and overpressure interacting with the structure.

Dynamic loading - Transient ^{wind} ~~blast~~ of the blast

Diffraction loading - bending of blast around corners.

Q4 =
4

4

Q5 =
4

4

- ⑥ Ballistic life is the length of time where a propellant continues to perform within set ballistic parameters, i.e. the burn rate is reliable. Ballistic life of gun propellants tends to be much less than the chemical stability life.

Factors affecting ballistic life -

Stabiliser content

Operating and storage conditions

- ⑦ a) Attack of aircraft -

Blast is a poor mechanism to defeat aircraft as it is affected by altitude and distance. External blast is not used as a primary method of attacking aircraft, but blast internally would be effective. For this the warhead would have to impact and perforate the target.

Shaped charge jets and explosively formed projectiles are ~~not~~ less effective against aircraft due to the fact that these warhead mechanisms rely heavily on hitting the target directly, which can be difficult to achieve for aircraft.

Fragmentation is the primary mechanism to defeat aircraft. Fragments can form naturally or can be preformed. An aircraft has many vulnerable/critical components and a relatively low KED (kinetic energy density) of fragments required to defeat it.

Q6 =
3

3

A warhead relying on fragmentation can use a smaller ^{explosive} warhead size to provide the optimum fragment size and also enables the missile system to be smaller/lighter, easier to carry.

A type of preformed fragmentation is continuous expanding rod that expands when the warhead detonates resulting in an effective dispersal of fragmentation.

High Velocity missile systems, such as star streak, use kinetic energy to achieve target effects against aircraft. The high velocity darts have to hit the target for it to be effective. The issue with kinetic energy ammunition is that they can pass through a target without destroying it. For this reason, the star streak darts have a small explosive ^{charge} ~~component~~ that initiates on impact to deform the dart and helps to dump the energy into the target.

Q7a
=4

b) Attack on Submarine -

Fragmentation is a poor mechanism for defeating underwater targets and are not used in warheads designed to defeat submarines.

The two main ways to defeat submarines is by using blast, via sea mines or depth charges, or using torpedoes. Torpedoes can use blast, ~~but~~ ^{most} modern torpedoes utilise shaped charge jet warheads.

Q7b
=12

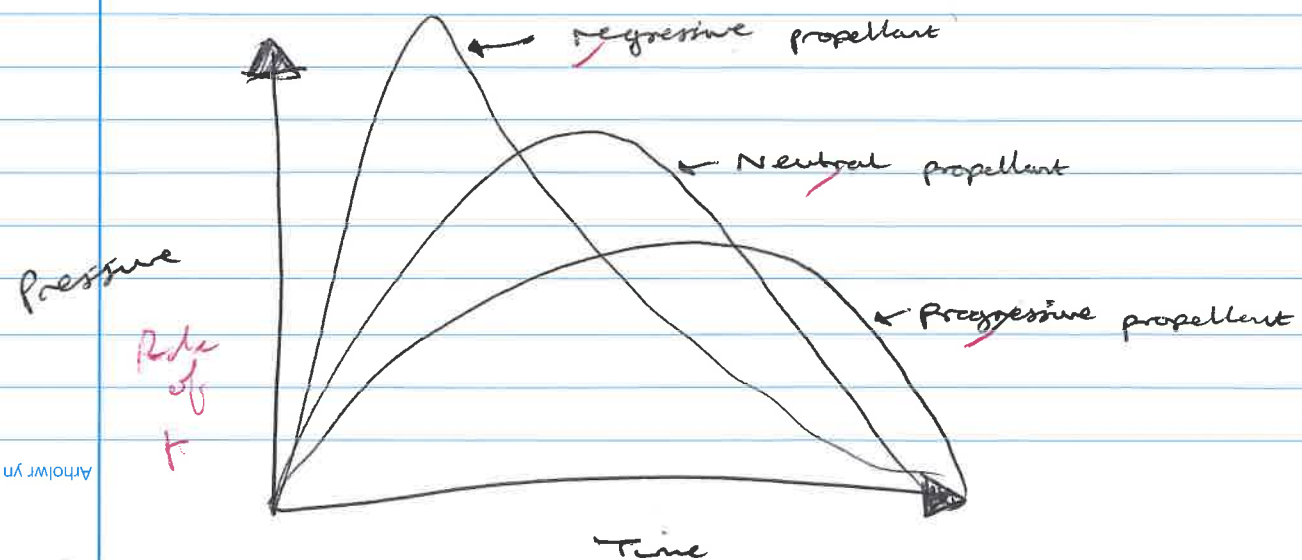
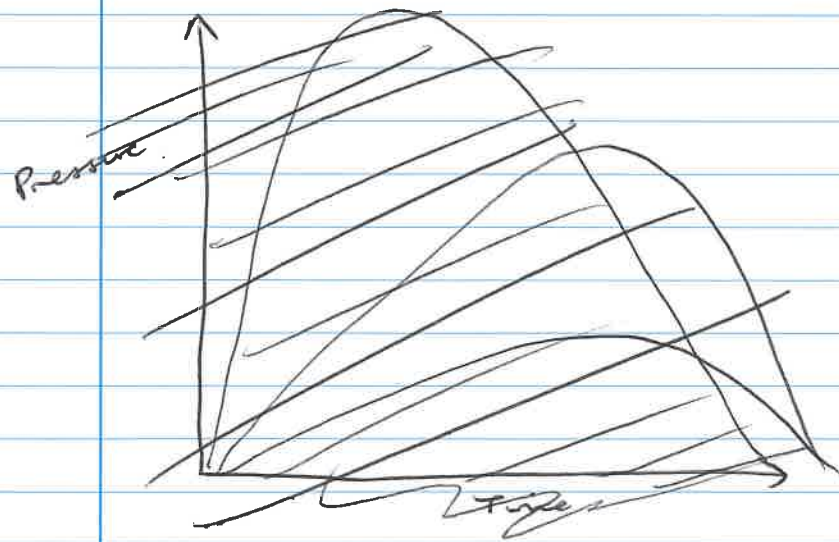
For a blast warhead to be effective it would have to be a large charge size which ~~would hamper~~ which is why it is more suited to mines rather than for torpedoes. ~~Shaped charge~~ The overpressure and shock effects are improved with depth so sea bed mines and depth charges can be effective against submarines.

Q7 Total
=14+12
=28

Spearfish torpedo uses a shaped charge jet warhead which is designed to impact the target. The formed SCJ then has to perforate the outer hull, water tanks and inner pressurised hull. As with all SCJ warheads, the angle of attack is important to achieve ~~the~~ the perforation required. Using a SCJ allows the torpedo to carry a relatively small explosive charge size, thereby maintaining good velocity and range.

A sea mine or depth charge when detonated nearby to a submarine exerts shock and blast. The gaseous products form a bubble pulse which expands and contracts and this changing in pressure can damage the submarine hull.

- Propellant helps to
- 8) a) ~~Propellant~~ grain shape determines the burning rate of the propellant. A grain that decreases in surface area as it burns is called regressive. A grain that increases in surface area during burning is called progressive. Neutral grains burn consistently.



example grain shapes -



cylindrical - regressive ✓



Multi-tubular - progressive ✓

b) Next generation gun propellants properties -

- Minimal barrel wear ✓
- Cheap ✓
- High ~~impulse energy~~ and burn rate in gun ✓
- pressures, but lower at ambient pressures.
- less susceptible to friction, impact etc ✓
- Safe to store & transport ✓

c) NC based gun propellants contain nitrate ester groups. These NO_2 groups require stabilisers to be included to counter/delay the decomposition process and enable them to be safe for a determined shelf-life. This means that NC gun propellants require extensive in-service surveillance and stabiliser depletion testing to ensure that it is still safe to store, handle, use.

There is a risk with NC based propellants that this decomposition occurs faster

Q8a
=6
8

Q8b
=2.5
2.5

than ^{anticipated} ~~intended~~ and results in an auto-catalytic decomposition and ignition. NC is also difficult to handle and manufacture. ✓

New propellants have been introduced to eliminate this risk. One method is to remove the NC from the composition altogether and relies on the main composition being RDX. The burning characteristics of this RDX based solid explosive are ^{good, it provides a lot of} ~~comparable~~ and energy, and it adds safety. It is less susceptible to friction/impact etc and it is also much more difficult to ignite. ✓

Low vulnerability ammunition is also being developed and introduced (LOVA). ✓

Liquid propellants are now being developed as they offer many advantages to conventional gun propellants (including NC based propellants). They can be relatively cheap to manufacture, are safe to store/transport, cause less erosion and ~~less~~ barrel wear. Liquid propellants can also be altered/modified much easier to determine a more accurate range. The down side to liquid propellants is the increased complexity to gun design. ✓

Q8
= 8

Q8
Total =
= 6 + 2 + 8
= 16.5