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A Level in Design and Technology:

Design Engineering (H404/02)

Problem Solving in Design Engineering

Sample Resource Booklet Version 3.1

Date – Morning/Afternoon

Time allowed: 1 hour 45 minutes

You must have:
• the Question Paper

INSTRUCTIONS

- You must read this Resource Booklet through before answering any questions.
- The recommended reading time for this Resource Booklet is **35 minutes.**
- This Resource Booklet is to be used when answering all questions.
- The question paper tells you when to refer to the information contained in this Resource Booklet.
- This document consists of **8** pages. Any blank pages are indicated.

INFORMATION

- Do not send this Resource Booklet for marking, it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

The stimulus in this booklet relates to issues and problems that may be encountered by military personnel when on active service and when working in their capacity supporting natural disasters.

PART 1

Military Technology:

Throughout history, advances in military capability have been fuelled by innovation. All branches of the military consistently have managed to use technology in new and creative ways.

Military operations of the past decade exposed an “innovation gap” that forced the military to react to the tactics of others rather than anticipating them. The Ministry of Defence research and development divisions were slow to respond with new and improved weapons and equipment based on changing threats. Critics have called for researchers to stop wasting money on science projects that target undefined hypothetical situations, and focus on systems that they know deployed forces need and to move them into the field in weeks or months, rather than years or decades. Innovation is not helpful if it’s not assisting troops actively deployed. As many senior officials have noted, an 80-percent solution that can be available in months is better than a perfect outcome that could take years or decades to achieve.

Some examples of innovation are faster and quieter helicopters, advanced crowd-control weapons, lighter infantry equipment that doesn’t overburden troops, ultra-light trucks and better battlefield communications.

Renewable energy that reduces the military’s dependence on fuel supplies is critical. Transporting fuel to the site of military operations has become one of the most dangerous missions because others know military machinery depends on it. Almost anything that helps reduce that demand for fuel is likely to be welcome.

Inventions that Lighten the Soldier's Load

For troops to survive on deployment, they must carry around a significant amount of equipment that includes, among other things, communication devices, weapons, ammunition and batteries.

But these items add significant weight to a soldier, who is already wearing heavy body armour. The rugged environment, for example, in Afghanistan, where troops trek up into the thin air of the mountains, has made it more imperative that scientists find ways to lighten a soldier’s pack load that can reach up to 50 kg.

The military is focused on reducing weight through technology and logistics. If soldiers can count on their food, water and ammunition being at a certain location when they arrive, then they have less weight to carry. The army is investigating increasing the use of precise, GPS-guided “smart” parachutes to drop more equipment from the air to the site of military operations.

Carrying energy storage is another difficult issue, Army officials said. Batteries needed to power radios and other electronic equipment account for a fifth of the total weight carried by soldiers on deployment. During a three-day mission soldiers will carry seven different types of batteries that can add up to 10 kg to their pack load.

British Army information

"The British Army is actively engaged in operational duties across the globe. The work we do ranges from peacekeeping to providing humanitarian aid, from enforcing anti-terrorism measures to helping combat the international drugs trade." (British Army Website)

Geographical information for locations where British troops are currently deployed

	Highest mountain altitude (m)	January				July			
		Mean temp. (°C)	Mean relative humidity (%)	Mean rainfall (mm /month)	Mean sunshine (hours /day)	Mean temp. (°C)	Mean relative humidity (%)	Mean rainfall (mm /month)	Mean sunshine (hours /day)
UK	**1344**	**4**	**88**	**78**	**1.7**	**18**	**72**	**45**	**6.6**
Afghanistan	**7492**	**-3**	**58**	**28**	**5.9**	**25**	**25**	**7**	**11.4**
Brunei	**1850**	**27**	**98**	**320**	**6.8**	**27**	**56**	**203**	**7.4**
Iraq	**3611**	**10**	**71**	**26**	**6.2**	**34**	**22**	**0**	**11.2**

Results of research into kettles, water heaters and other thermal products

Product	Product information	Primary material and manufacturing method	Technical information
 	Jug kettles Auto switch off Cordless (lift off base) Blue LED illumination	Polypropylene Injection moulded Glass Moulded and bonded to polymer base	Volume 1.7 litres Voltage 230V Power 3kW
	Stove kettle	Aluminium Deep drawn or spin moulded	Volume 1.5 litres

Product	Product information	Primary material and manufacturing method	Technical information
	Thermal mug Leakproof screw-on lid with autoseal push-button drinking spout	**Body:** Stainless steel, double-walled with vacuum in between for thermal insulation. Deep drawn or spin moulded Painted finish **Lid:** Polymer, multiple parts, injection moulded	Volume 470 ml
	Thermal flask Cup screws on to top of flask	**Body:** Stainless steel, double-walled with vacuum in between for thermal insulation. Deep drawn or spin moulded Polished finish **Lid and cup liner:** Polymer Injection moulded	Volume 500 ml
	Car kettle Fitted with car power connector	**Main material:** polymer	Volume 750 cm3 Voltage 12V Power 200W
	12V water heater Fitted with car power connector Heater is immersed in a cup of water		12V 120W
	Pizza delivery bag Lined with reflective material to reduce radiant heat loss	Nylon textile bag. Double-walled with polymer foam in between. Aluminium-coated polymer film lining	
	Take away food container	Expanded polystyrene	

Material data

Material	Density ($g\ cm^{-3}$)	Ultimate tensile strength (MPa)	Max continuous use temperature (°C)
Polypropylene	0.95	40	210
ABS	1.06	45	95
Nylon	1.1	120	185
Glass	2.6	33	230
Aluminium	2.7	300	150
Stainless steel	7.8	505	800
Expanded polystyrene	0.02	0.1	80

Results of Research into Portable Electrical Power Sources

Product	Product Information	Specification
	USB battery pack Various sizes and capacities available	5V 10 000 mAh capacity Mass 250 g
	Lead acid battery Various sizes and capacities available	12V 7200 mAh capacity Mass 2.2 kg
	Alkaline AA cells Various sizes and capacities available	For each cell: 1.5V 2500 mAh Mass 23 g
	Roadside sign powered by wind generator and rigid solar panel	Wind generator output in a fresh breeze: 12V 2A Solar panel output in bright sunshine: 12V 1.3A
	Backpack with flexible solar panel	Solar panel output in bright sunshine: 12V 0.5A

Heat capacity formula: $Q = mc\Delta T$

where: Q is heat energy (J)
m is mass of water (kg)
c is the specific heat capacity of water ($c = 4200\ J\ kg^{-1}\ °C^{-1}$)
ΔT is temperature rise (°C).

PART 2

Disaster Response: The Role of a Humanitarian Military

When disaster strikes, response must be rapid, coordinated and appropriate to ensure that crisis is mitigated by effective delivery of relief and aid. Recent catastrophes in Japan, New Zealand and Haiti cast a spotlight on the role of military forces in the organisation and process of disaster relief, calling for standardised military disaster relief.

"International experience has shown that major disasters almost immediately overwhelm local emergency services. Humanitarian relief is increasingly a core task for all defence forces," said New Zealand's defence minister Wayne Mapp, adding it should be the main part of "military business, not simply a secondary task."

The surprise and devastating nature of natural catastrophes calls for a massive coordinated reaction on short notice. While the primary responsibility for disaster response lies with civilian agencies at local levels, only the military has the manpower, equipment, training and organisation necessary to gather the relief effort required during catastrophic incident recovery.

There are areas where armed forces unquestionably can offer unique capabilities, primarily in transport, logistics and the ability to deploy immediate help. Most modern armies today have made disaster relief an important part of their programmes, offering rapid response, performing medical assistance, logistical support, air traffic response, aid distribution, protection and recovery in natural disasters on a global scale.

The main reason to employ militaries is timeliness. Armies have not only the necessary equipment to supply large quantities of relief products to the disaster areas, but their helicopters can support search-and-rescue operations. The timely arrival of soldiers and officers is essential to the course of events in a crisis.

The cost of deploying army forces is generally higher than for civilian assets. This has caused concerns that foreign military assets place a disproportionate burden on humanitarian funds. However, several countries have introduced measures whereby their defence ministry covers some or all of the costs for overseas disaster relief, reducing their impact on humanitarian aid budgets.

To overcome coordination issues, simulation and training must be conducted on a regular basis. Soldiers and officers, in cooperation with civilian authorities such as the police, fire services and first aid providers, have to prepare for how to organise a successful response to any disaster.

Rescuers helping civilians during a flood

A road bridge washed-away by flooding

UK flooding emergency relief bridge

The British army require a temporary pedestrian bridge for use in such situations. Once in place, the bridge must be self-supporting and must be able to span a maximum gap of 5.0 m as shown in **Fig.1**. The bridge would need to be transported on a car trailer, as shown in **Fig.2**, and it must be able to be assembled and put into place across the gap by a team of 6 army personnel.

Fig. 1 Minimum bridging gap

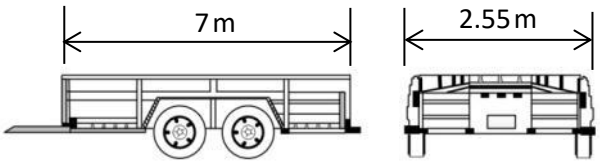
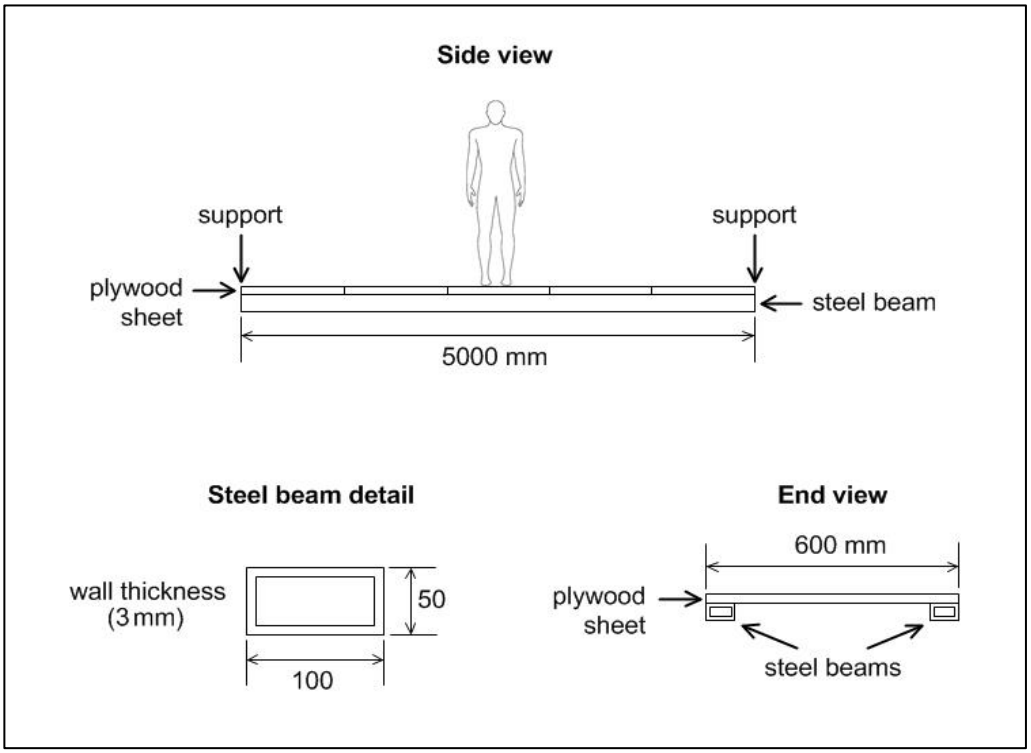


Fig. 2 Maximum UK car trailer dimensions



(not to scale)
Fig.3

Available mild steel beams

Beam profile	**Available stock sizes (mm)**	**Maximum length (m)**	**Mass per metre length (kg m^{-1})**
Flat bar	50 × 8 75 × 6	6 6	3.2 3.6
Rectangular box	50 × 50 (wall thickness 3) 100 × 50 (wall thickness 3) 200 × 100 (wall thickness 8)	6 6 2	4.5 6.8 35.9
I beam	127 × 76 (wall thickness 13) 178 × 102 (wall thickness 19)	8 8	13.0 19.0

Materials data

Material	Young's Modulus (GPa)	Density (kg m^{-3})
Mild steel	200	7800
Aluminium	69	2700

Plywood

Thickness	Mass per m^2 (kg m^{-2})
12 mm	7.3
18 mm	11.0

Summary of updates

Date	Version	Details
April 2022	3.1	Updated copyright acknowledgements. .