



Oxford Cambridge and RSA

Friday 16 October 2020 – Morning

**A Level in Design and Technology:
Design Engineering**

H404/02 Problem Solving in Design Engineering

Resource Booklet

Time allowed: 1 hour 45 minutes



INSTRUCTIONS

- Use the Resource Booklet to answer all the questions.
- You should spend **35 minutes** reading this Resource Booklet.
- Do **not** send this Resource Booklet for marking. Keep it in the centre or recycle it.

INFORMATION

- This document has **8** pages.

ADVICE

- Read this Resource Booklet carefully before you start your answers.

The stimulus in this booklet relates to issues and opportunities encountered when using and designing fitness equipment.

Personal Fitness

According to estimates from Public Health England, two thirds of adults and a quarter of children between two and 10 years old are overweight or obese. Obese children are more likely to become overweight adults and suffer premature ill health and mortality. By 2034, 70% of adults are expected to be overweight or obese.

Estimates suggest that obesity cost the NHS £5.1 billion in 2006/7. This is more than the £3.3 billion attributed to smoking-related ill health and £3.3 billion attributed to alcohol-related ill health.

Much has been done over the last few years to try and combat the growing problem of obesity. Initiatives range from increasing taxes on certain foods through to improving school dinners. The Government has spent millions trying to encourage people to live a healthier lifestyle but the numbers of obese adults and children is still increasing.

The NHS has stated that being fit and healthy can help improve someone's mental wellbeing. According to figures published by NHS England in 2016/17, £9.27 billion was spent on mental health services.



Fig. 1

Many adults aged 65 and over spend, on average, 10 hours or more each day sitting or lying down, making them the most sedentary age group. They are paying a high price for their inactivity, with higher rates of falls, obesity, heart disease and early death compared with the general population. With increasing age, it becomes even more important to remain active in order to stay healthy and maintain an independent lifestyle. Many gyms now run classes for the over-65's to encourage them to get active and improve their way of life.

NHS England has helped by introducing funded gym places to adults who are over 65. The leisure industry has also noted this and more gyms are offering over-65 classes in a variety of low impact activities, from aerobics to walking football.

Diversification of market

Figures from the 2018 'State of the UK Fitness Industry' report indicate that the fitness industry has grown 15% in the last 5 years with 1 in 7 people having membership to a gym. The industry is worth £5 billion and the aim is to increase this by 20% by 2020. These figures do not take into account the people who do physical workouts at home. The development of the home gym has grown in the last five years, with many people choosing to workout in the comfort of their own home during their spare time. Fitness programs have been developed by various global companies to enable this to happen. The use of social media and the internet have allowed people to have a virtual personal trainer in their home. Online group yoga and social cycle-machine groups have been set up for people to communicate and workout 'together' with others from all over the world.



Fig. 2

The emotional benefits of physical activity

Exercise releases feel-good chemicals in the brain such as endorphins which can boost one's mood. Endorphins are the same chemicals that help the body manage pain. This explains why endorphins also have the power to make people feel better and why something as simple as a jog or brisk walk can instantly improve how we feel. These chemicals in the brain make us feel more positive and focused, allowing us to let go of any stress we may be feeling.

Regular physical activity also improves self-image which increases confidence. People who exercise regularly are typically trying to meet their fitness goals. When they see the results of their hard work, they feel empowered and accomplished. As regular physical activity helps maintain a healthy weight, people generally become happier with their physical appearance.

The social benefits of physical activity

People with high self-esteem and self-confidence tend to have good social relationships and they enjoy social interactions. Physically active people often develop new friendships through their activities because they have opportunities to meet new like-minded people. These could be people running the same route or new contacts made with people through yoga or cycling classes, for example. People are often more motivated to do hard physical workouts if they do it with someone else.

Developing social relationship skills can have other benefits beyond the gym or other social environments. For many people, their daily job requires them to deal with other people, or to present or perform to large groups. Such people frequently speak of the benefits that staying active in their personal lives also has on their professional life.

Rowing Machine Charging System

The Rowmatic-1 rowing machine

The Rowmatic-1 is a rowing machine for the modern gym user. Its ergonomic design and interactive user interface make it an easy system for novices and for seasoned gym users.

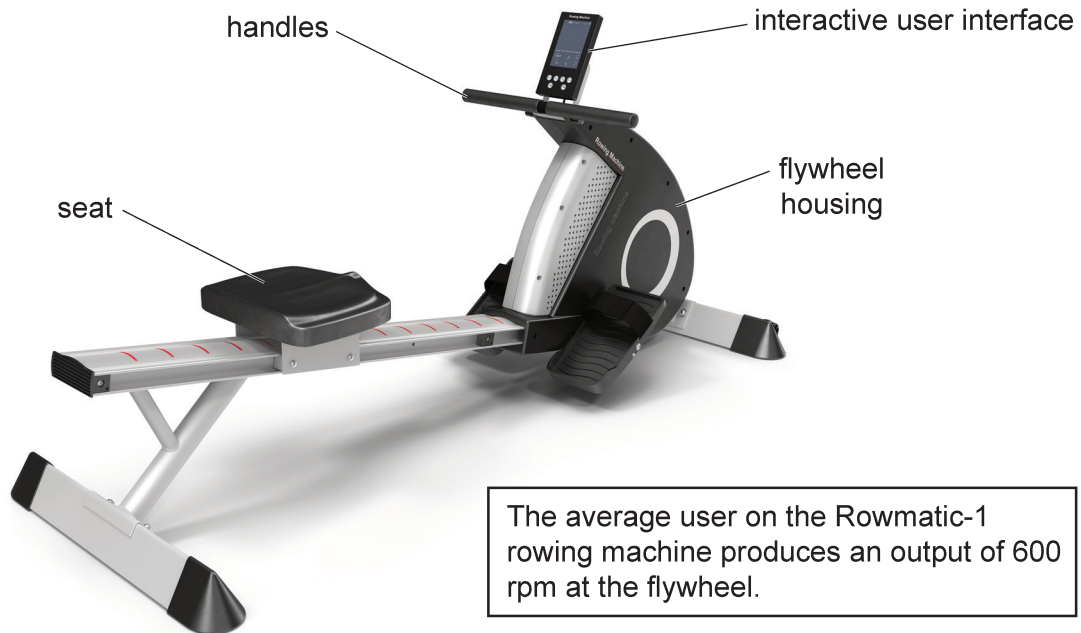


Fig. 3 – Rowmatic-1 rowing machine

Mobile devices used by gym users

Fig. 4 shows the results of a survey of gym users to investigate which electronic mobile devices are brought to a gym workout session.

Device	Charging connection method	Battery capacity (mAh)
Smart phone 1	Lightning 2	1810
Smart phone 2	Wireless	3300
Tablet	USB – C	3800
Clock radio	Micro USB	900
Action camera	Micro USB	1220
Portable music player	USB Mini A	100

Fig. 4

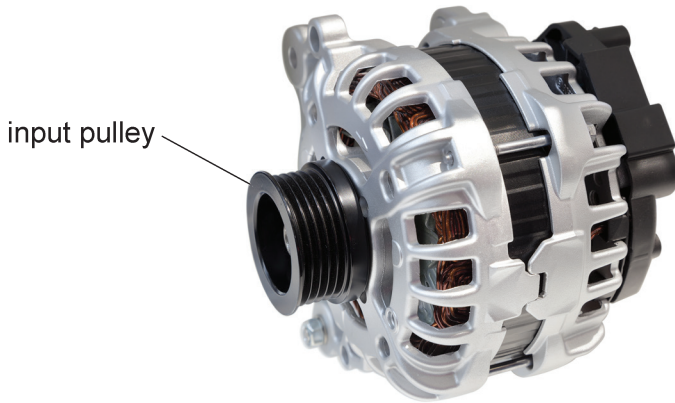
The gym environment

A modern gym is a bright, air-conditioned environment, filled with a wide range of fitness equipment. It can be very busy with users at peak times. Motivational music is often playing and some users like to use apps and listen to their own music through headphones connected to their personal electronic devices. Many gyms require their members to undergo induction training to ensure that they understand how to use the equipment safely.



Fig. 5

TB-401/10 generator



Output voltage (>1000 rpm)	5 VDC
Output current (@3000 rpm)	7 A
Maximum rotational speed	20 000 rpm
Maximum operating temperature	120 °C
Input pulley diameter	50 mm

Fig. 6 – TB-401/10 generator information

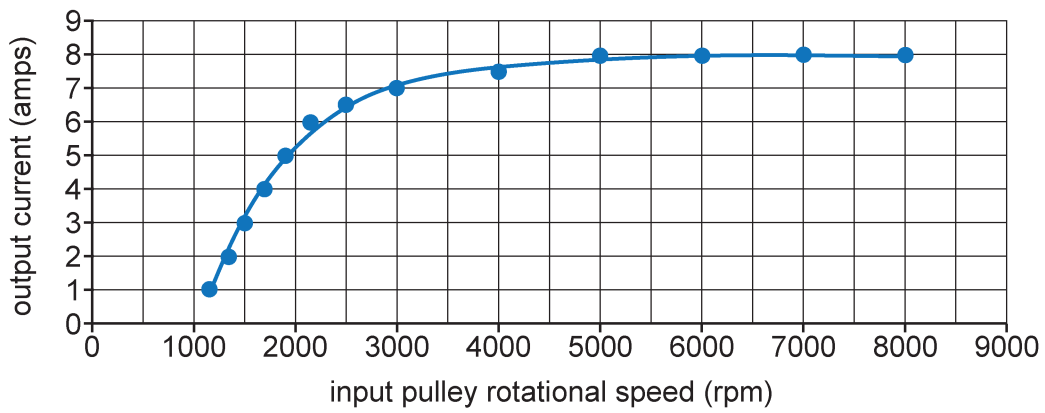


Fig. 7 – TB-401/10 generator output graph

iPhone charging specification



Battery type	Non-removable Li-ion
Battery capacity	1810 mAh
Charging current	3A
Charging voltage	5VDC
Charge connector	Lightning 2

Fig. 8 – iPhone charging specification

The Increase in the Popularity of Cycling

Cycling has increased in popularity in the last decade with 5.6% of the population currently cycling at least 3 times a week. This increase has partly happened due to government incentives such as the Cycle to Work scheme and the London Cycle Hire scheme. Both schemes encourage people to leave the car at home and get out on their bicycle.

As well as people cycling to work, many people cycle for recreation which means transporting their bikes throughout the country to various cycling locations.

The Bike-ease roof-mounted bicycle rack

Designers have a range of digital design tools at their disposal from CAD systems through to photo-editing software, all of which enable design engineers to easily visualise their designs and make them easier to communicate to others. Within the development of the Bike-ease roof-mounted bicycle rack design engineers would have used a variety of digital design tools to help with the design process. These digital design tools would have greatly assisted design engineers in not only visualising the concept, but also virtually testing the suitability of designs before going to testing.

The Bike-ease bicycle rack is designed to be mounted on the roof of a car. It provides assistance to the user by lifting a bicycle onto the car roof, using the force generated by a pneumatic cylinder.

Fig. 9a and **Fig. 9b** show the Bike-ease bicycle rack mechanism in its lowered and in its raised positions.

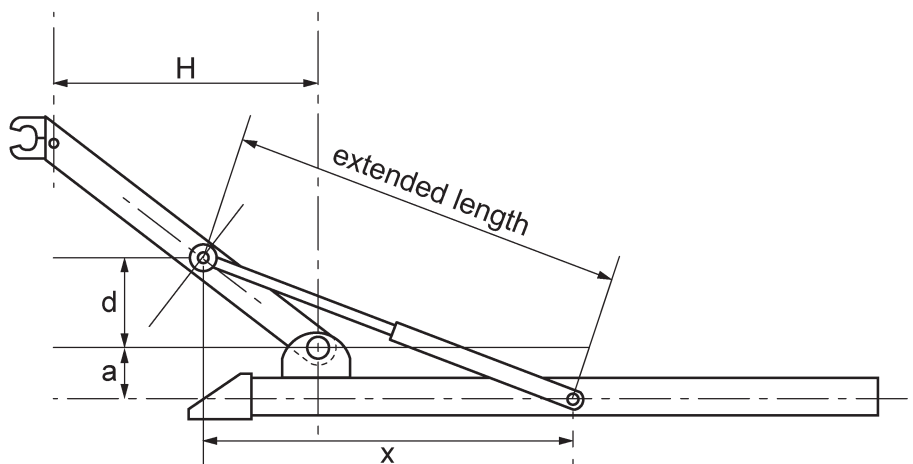
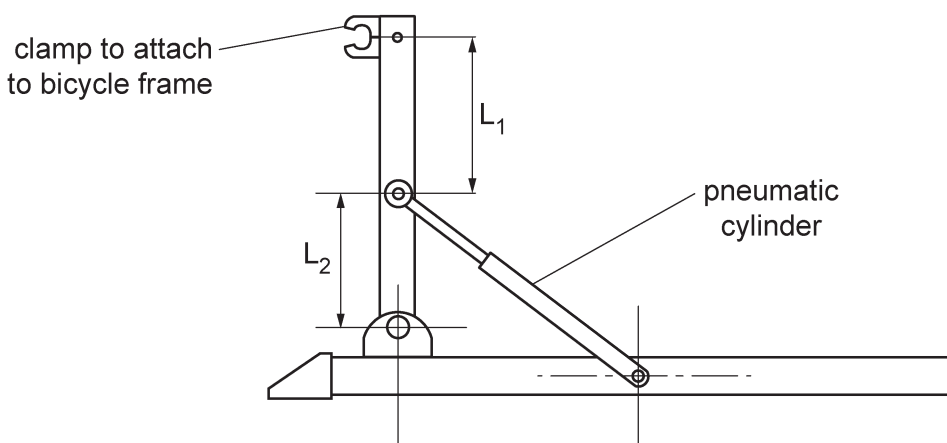


Fig. 9a – Bike-ease bicycle rack in lowered position, with pneumatic cylinder extended.



Diagrams
not to scale

Fig. 9b – Bike-ease bicycle rack in raised, vertical position.

Values for the labelled dimensions in **Fig. 9a** and **Fig. 9b** are shown in **Fig. 9c** below:

a	100 mm
d	200 mm
x	750 mm
L ₁	340 mm
L ₂	300 mm

Fig. 9c

Pneumatic cylinders available for use in Bike-ease design

Cylinder	Non-extended length (mm)	Maximum extended length (mm)	Diameter of cylinder bore (mm)	Diameter of piston rod (mm)
A	400	650	32	12
B	500	820	50	20
C	450	750	80	25
D	540	860	80	25

Fig. 10 – Data for the available pneumatic cylinders

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