



University of  
**Nottingham**

UK | CHINA | MALAYSIA

**Department of Mechanical, Materials &  
Manufacturing Engineering  
Design, Manufacture and Project  
MMME 2044**

Design, Make and Test

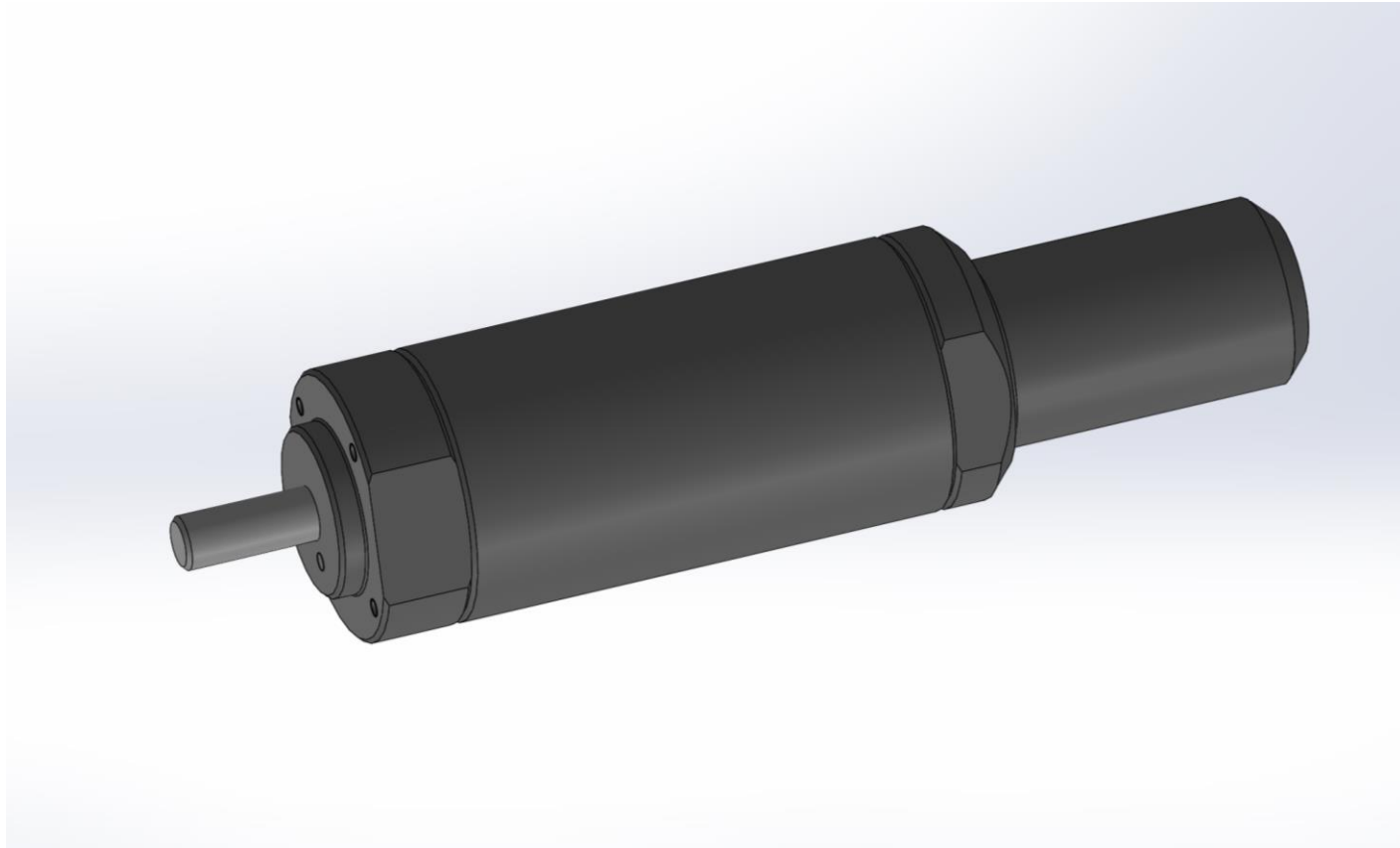
Air Motor

Professor G E Kirk

# Scenario

- You are a design team working for Universal Air Products (UAP)
- Universal Air Products (UAP) is a small, but successful, company who design, produce and service a range of pneumatic equipment that is used in a wide variety of applications. The business has grown steadily over the years and it has a reputation for delivering on time, robust, reliable and good quality products.
- They produce a range of mini geared air motors from 12 to 300W. One of the most successful is the TP12, capable of producing 90W, but its most frequent and popular use is de-rated to 12W at 600 rpm with air supply at 4 bar gauge. At this rating it has a very high reliability and long life greatly valued by the industry.
- Customers are delighted with its reliability and low vibration; however, it is rather more expensive to buy due to the high number of precision parts required which is somewhat offset by its long life. Customers may be attracted by a cheaper but less capable unit
- This unit is the market leader, 65-70% market share and one of the biggest contributors to the Company's financial performance and hence employment.

# The Universal Air Products (UAP) TP12 Air Motor



# The Competitor Challenge

- Rivale Air Products (RAP) is a company about the same size as UAP but it is part of a very large corporation, it has not been performing well in recent years. The product range is old, unreliable and their service reputation is poor.
- RAP have a new range of air motors in development which they claim, 'are designed to deliver the optimum performance of others in the market but are significantly cheaper'. The intention is to launch the first of the radical new design of air motor next year. They claim they have a market for at least 10000 units per year.

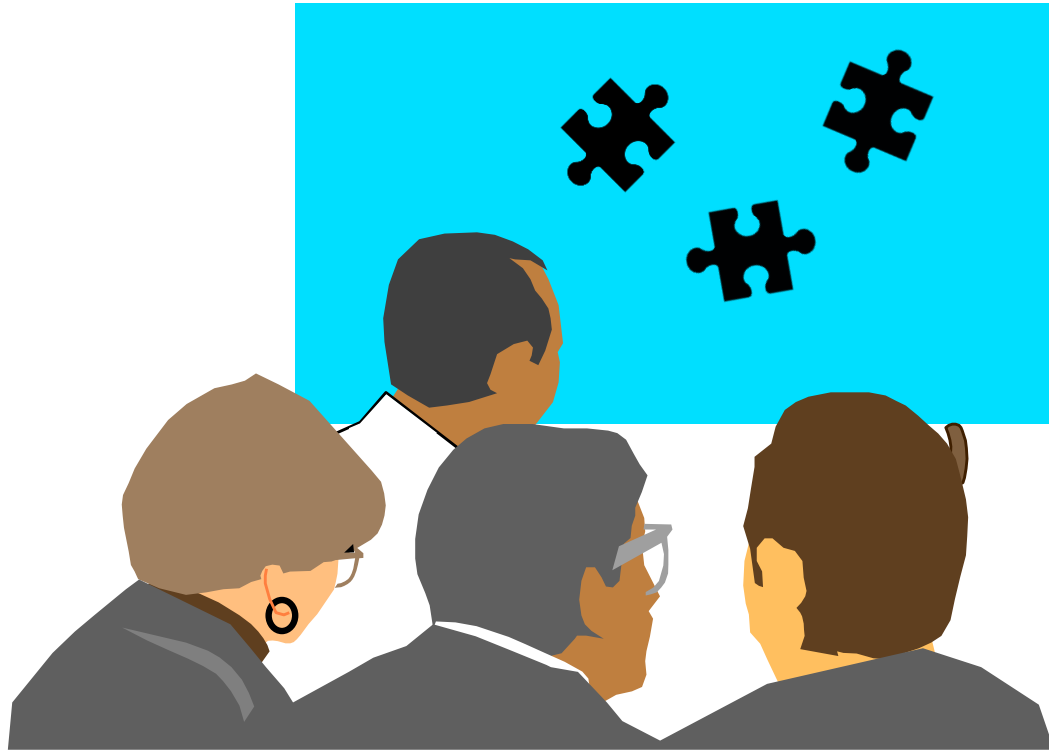
# The Competitor Challenge



# The Task

- The Board of UAP are rightly very concerned at this potential threat and have formed a Review Team with representatives from the Engineering, Sales, Aftermarket and Production departments to assess this threat from RAP and formulate a future product strategy.
- Your group are to provide the Engineering support to this Review Team. As the RAP proposal is in the early stages of development not a great deal of reliable information is available but there is enough to make some judgements on the 'most likely' scenario.
- UAP's problem is how to respond to this threat commercially or technically.
- You are required to advise your Board on the technical issues.
- The problem is that there are few technical facts available. There is only an RAP press release, see attached, and some information from friendly suppliers.
- The issue is to determine in absence of real facts what is 'most likely'

# The Task



# The Board's Questions

- What is the probable design concept/architecture of the RAP air motor?
- Is it likely to be capable of delivering the same performance in speed, power and torque as the TP12, 12W, 600rpm @4bar gauge?
- What would be the likely weaknesses of the design relative to the TP12?
- On a **qualitative** basis is it likely to be lower cost.?



# Deliverables

- An initial submission to the Board outlining the anticipated RAP motor and its likely performance.
- A final submission with all the necessary information to manufacture a prototype.
- A built and tested prototype of the anticipated RAP motor.

# Assessment

- Each group must make submissions in two parts:
  - A Preliminary Design Review (PDR)
  - A Critical Design Review (CDR).
  - See MMME 1024 Design notes for a fuller explanation of the roles PDRs and CDRs.
- A CDR feed back sheet will specify any Category 1 and 2 deficiencies and Observations.
- Any Category 1 and 2 Deficiencies will need to be closed out and approved by the appropriate tutor BEFORE the Group will be allowed to commence manufacture.

## **RAP to launch a new air motor**

Earlier this year The General Products Corporation installed a new management team in Rival Air Products. The new CEO is Art Bernoulli, a long term GP manager, who has a deserved reputation for turning around loss making companies.

Insiders say that he has two years to return the Company to profit or GP will close it down. Bernoulli has already overhauled the service organisation and is now turning his attention to RAP's product range which is considered by the industry to be out-dated. He intends to launch a new product range "in the near future"

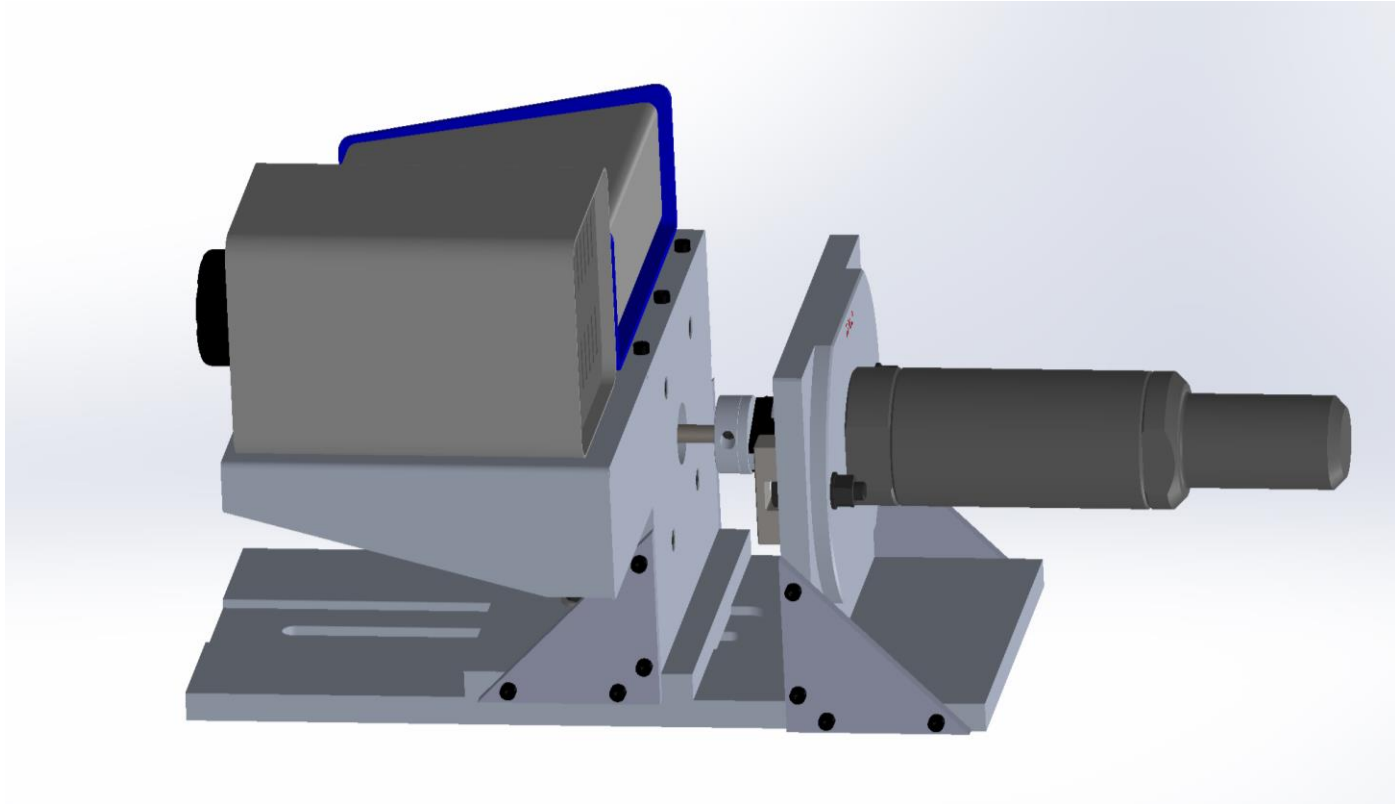
Bernoulli says "We will start production of the new 'Tripiston' range of air motors next year. It is a novel design, using the latest manufacturing processes, it will produce the same power as our current products, but with fewer parts and half the cost. We expect a market need for 10000 units annually".

"It will set new levels of reliability. Our engineers completed functional testing on ten prototypes and now are conducting final endurance testing on pre-production units to ensure a smooth entry into service"

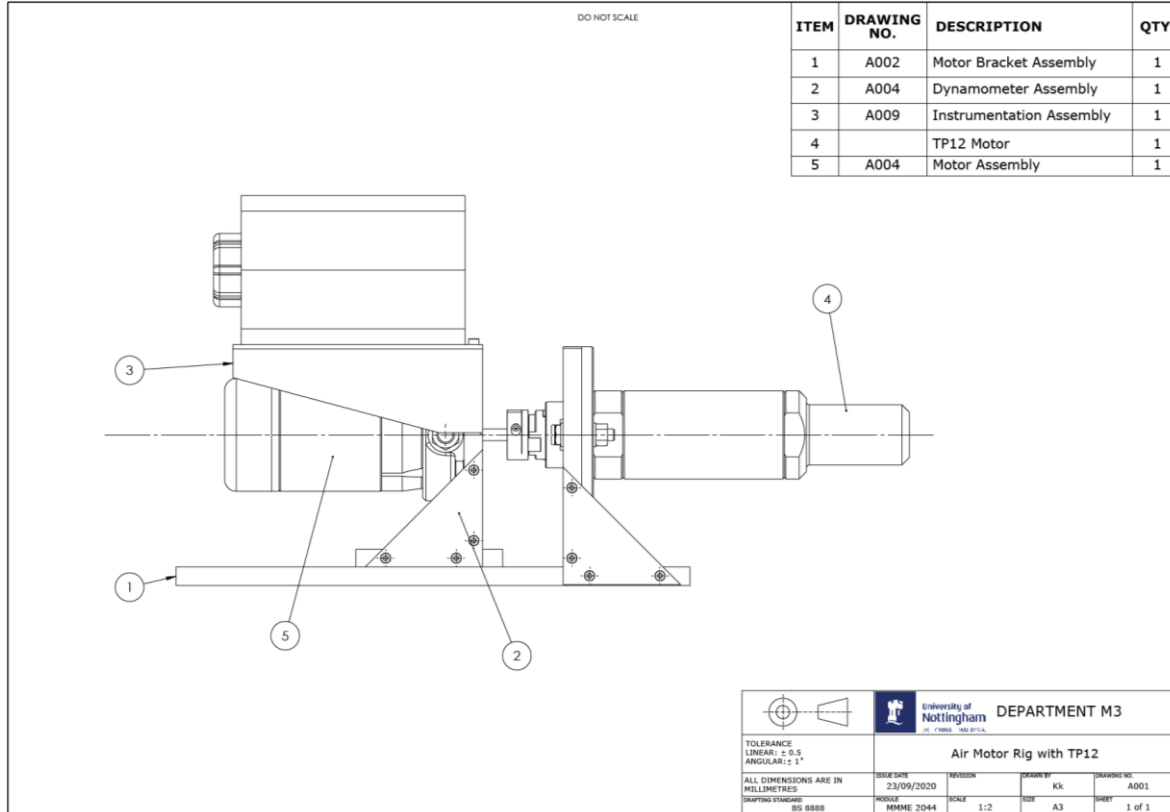
The only comment from rival and market leader UAP was that "We consider that we have an excellent product range and will continue to give our customers first class service with excellent value"

*Air Products Journal August 2022*

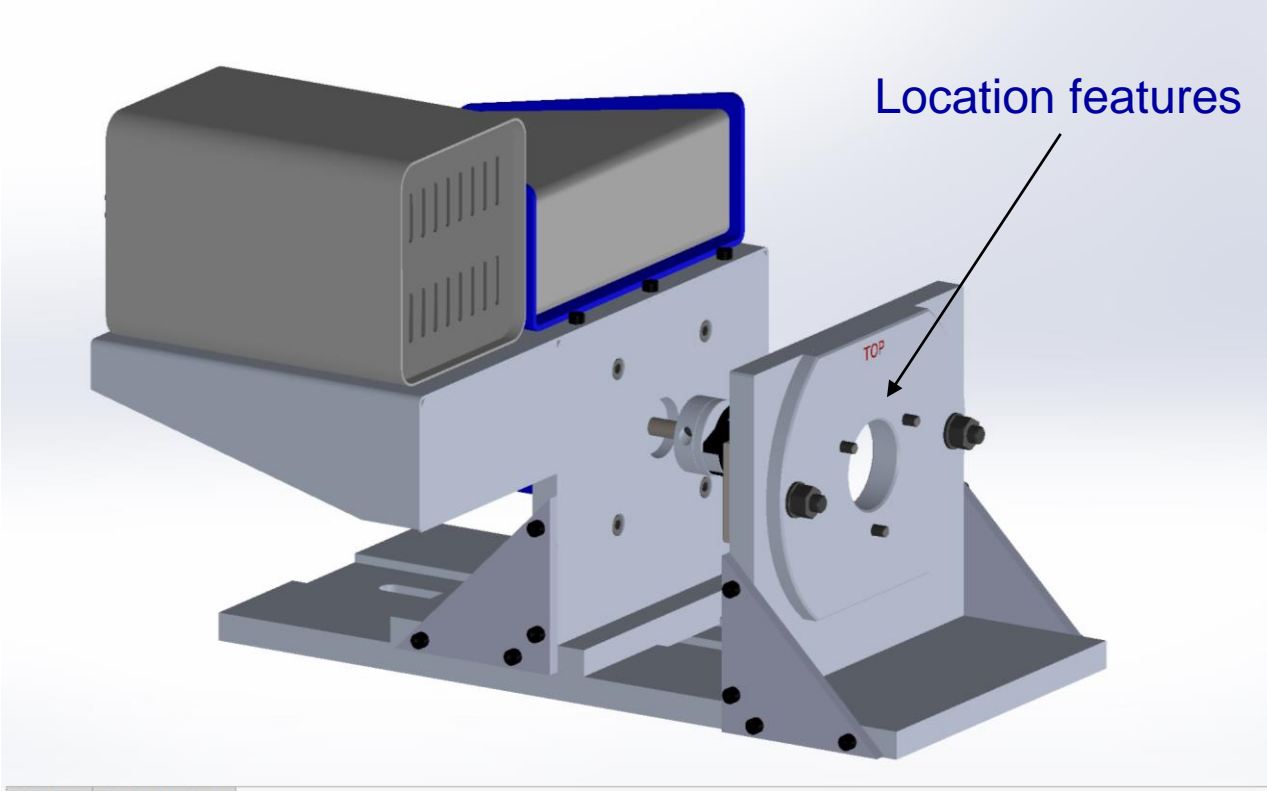
# The TP12 Test Rig



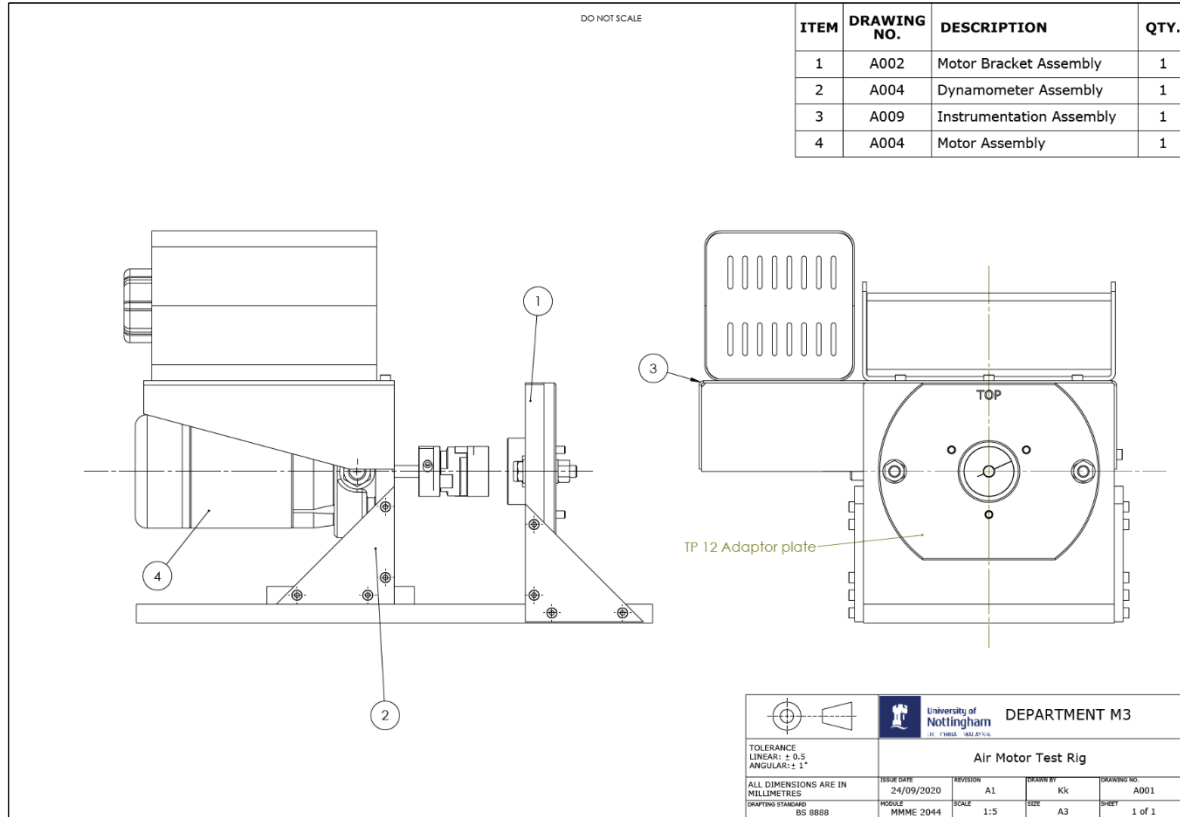
# The TP12 Test Rig



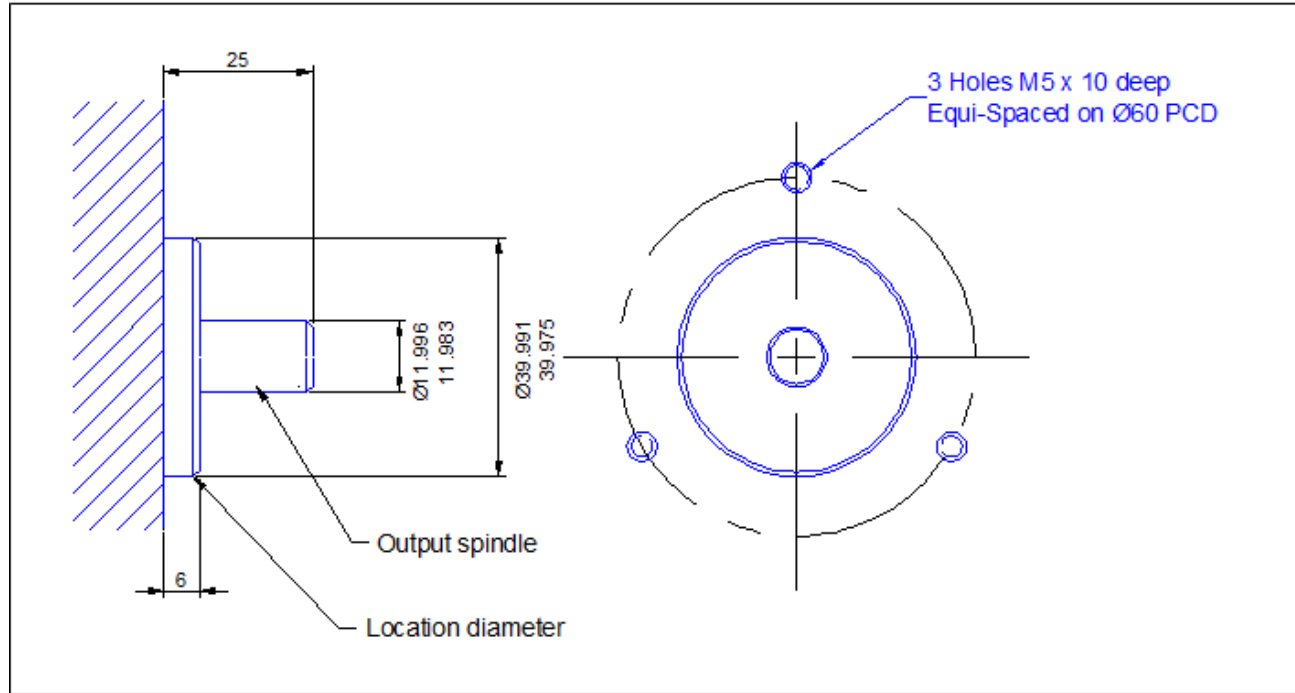
# The Basic Test Rig



# The Basic Test Rig



# The Rig Adaption – To Match the Location Features



This feature must be provided on the test unit in order to fit to the rig

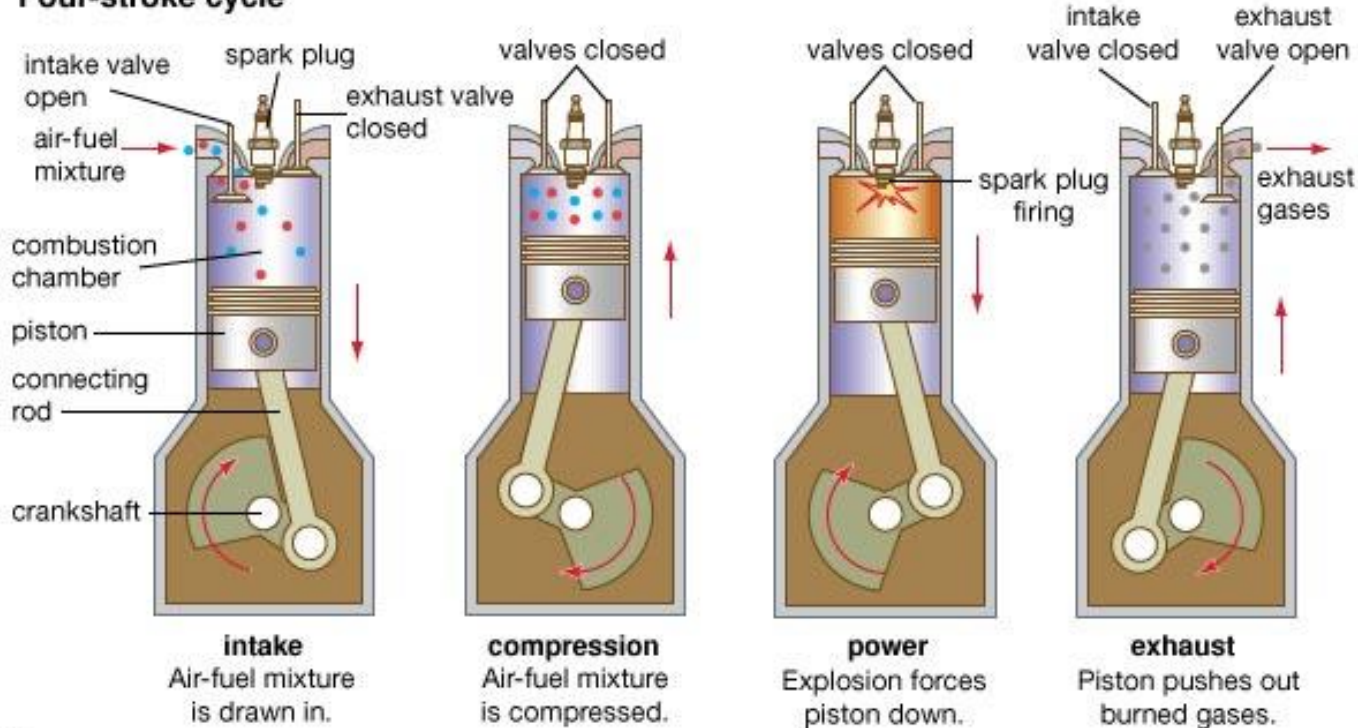


# Using Existing Technology

- In design it is not always necessary to develop new technologies
- The first Jet Engines utilised compressors derived from piston engine superchargers
- It meant that existing tried and tested technologies could be used but in a new application, reducing technical risk and bringing to fruition earlier.

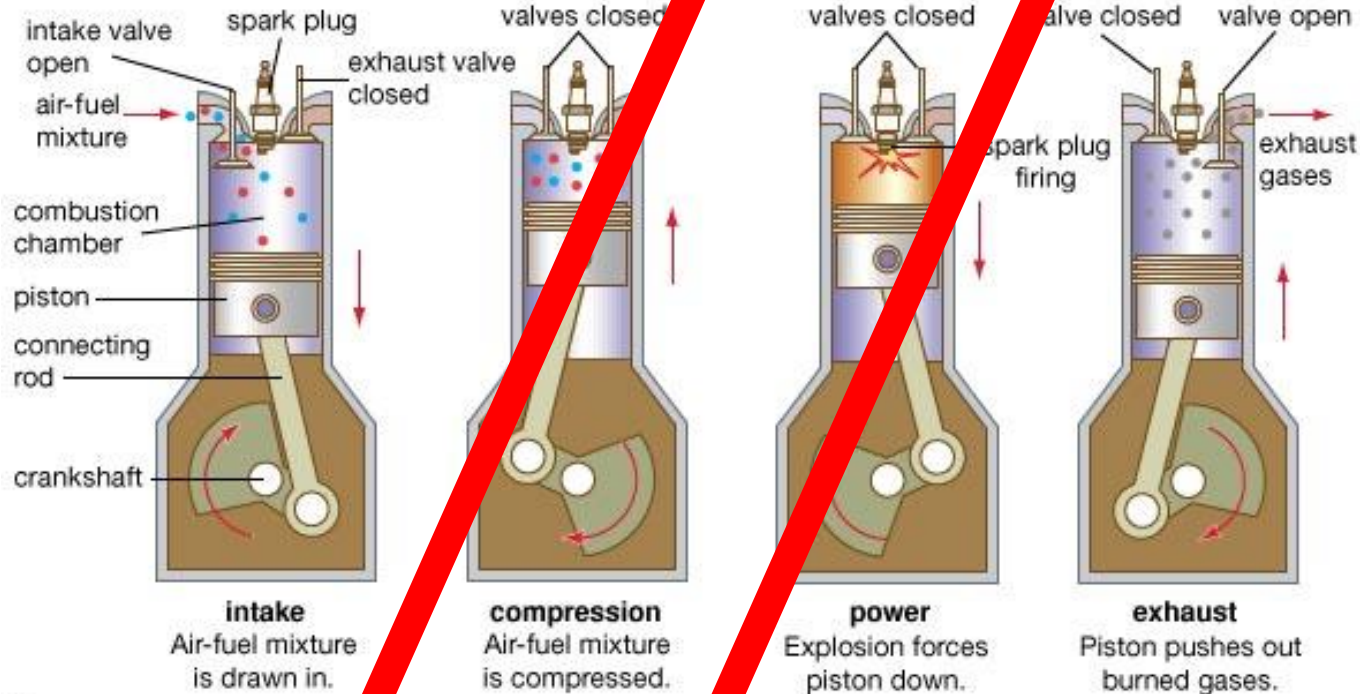
# The Four Stroke Internal Combustion Engine

## Four-stroke cycle

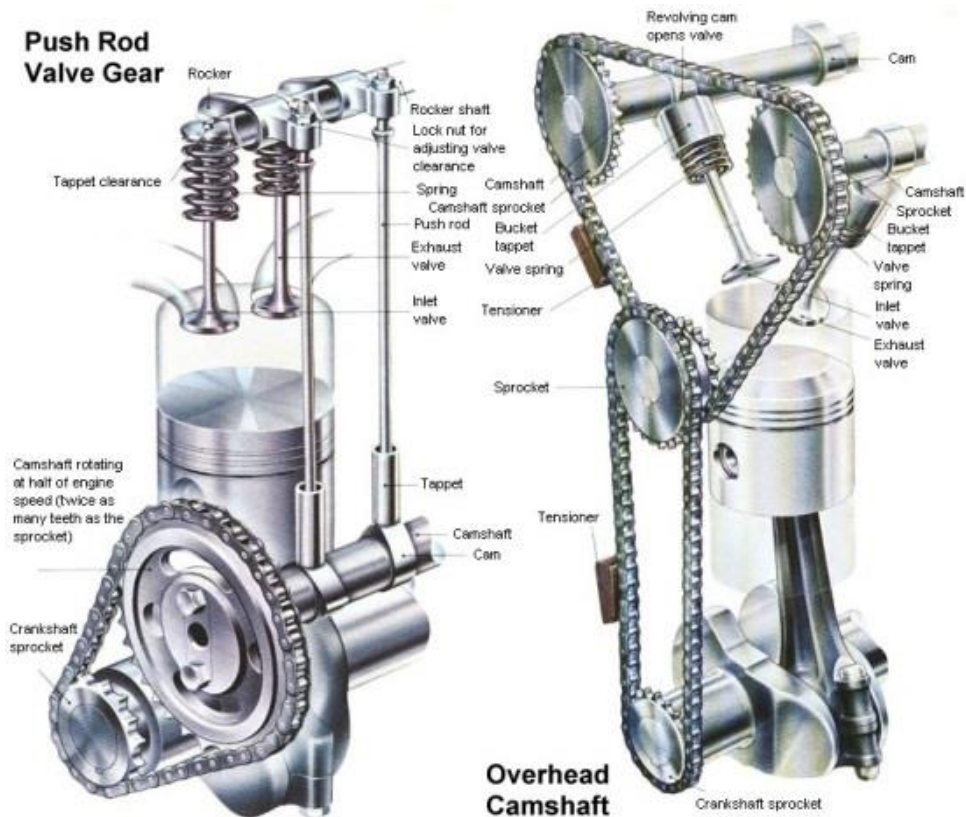


# A Reciprocating Engine Without Internal Combustion

## Four-stroke cycle

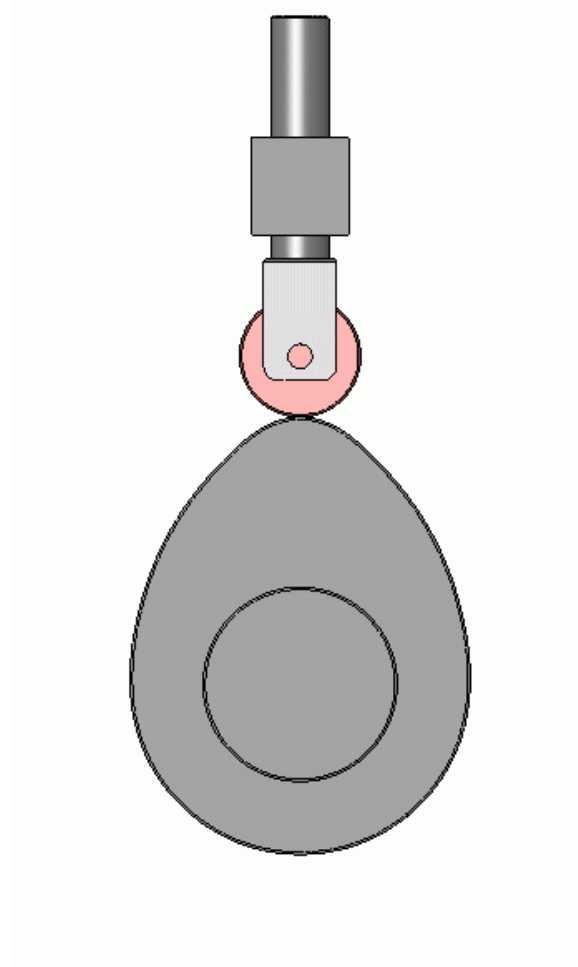


# Valve Timing



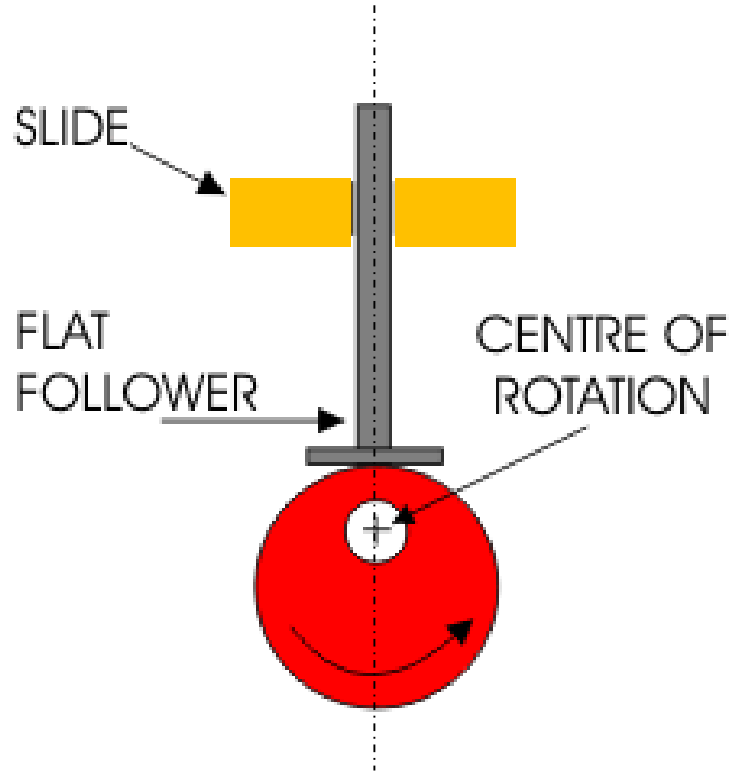
# A Practical Engine Cam

- In this case the motion is to open the valve followed by a period of rest

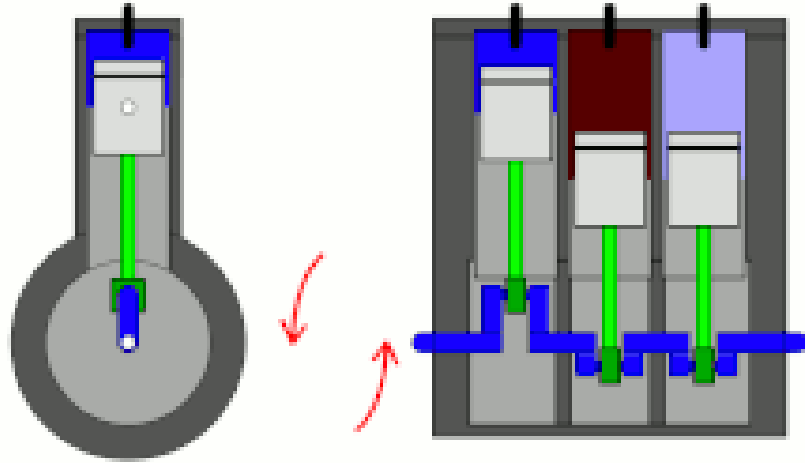


# A Circular Offset Cam

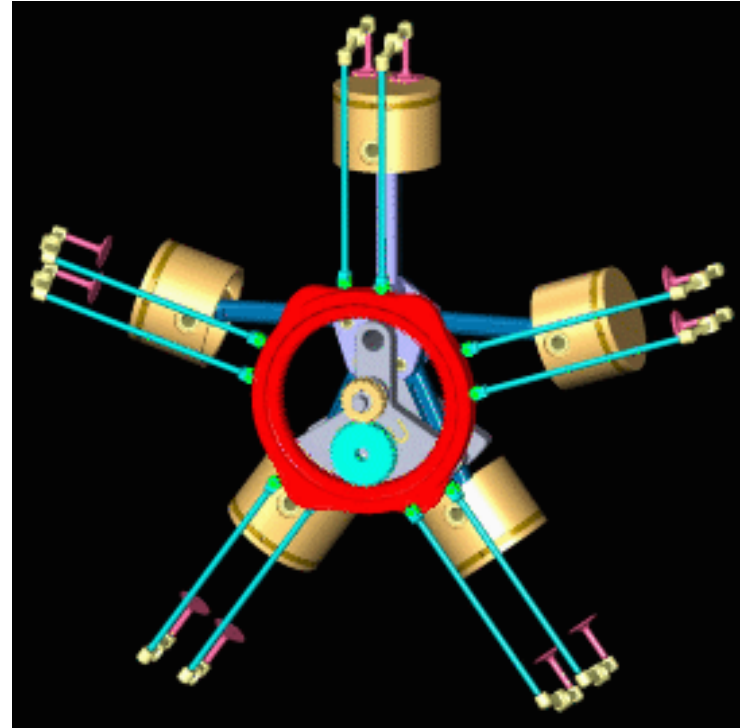
- In this case the motion is to continuous and the circular cam provides the power to move the cam follower,
- Think about the creative techniques in the lecture on Concept Generation, is that always the case?



# Engine Configurations



An Inline piston engine



A radial piston engine



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