

Marked 15/02/24
JM.

PCEE4010

Abstract ?

HNC Electronic and Electronic engineering and HNC instrumentation engineering,
? Pneumatics and Hydraulics Devices & Calculations Assignment

Relevant photo is
good on a cover page.

✓

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Refrain from Using personal email.
Student email is fine.

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Heather Raymond	Student ID number:	95699
Programme:	HNC Instrumentation Engineering		
Module:	Pneumatics and Hydraulics		
Module code:	PCEE4010	Contribution to Overall Module Assessment (%):	50%
Lecturer:	J Mowbray	Internal Verifier:	J Pointer
Assignment Title:	Pneumatics & Hydraulics Devices and Calculations (Assessment 1 of 2)	Word count (or equivalent):	2000
Submission deadline:	25/01/24	Return date of provisional marks & written feedback:	08/02/24
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

Module Learning Outcomes (from module syllabus)

1. Demonstrate an understanding of the construction, function and operation of pneumatic and hydraulic components, equipment and plant.

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*You have used figure numbering
in your report, your list
of figures should follow Toc.*

✓
Concise Toc.

Introduction

The aim of this assignment is to provide an introduction of the key aspects of pneumatic and hydraulic systems and how they compare to each other. The assignment will cover the following areas of pneumatics and hydraulics – power sources, pressure regulation, pressure drops, forces, gas laws. This will be achieved through a calculations and research work. ✓

Assignment Specific Instruction

Produce an engineering technical report that conveys your understanding of hydraulic and pneumatic systems.

Structure your report in accordance with the tasks below.

Use images, annotation, diagrams, tables, references, etc. to aid your written work.

The following methods are acceptable for presenting your calculations:

- *Word processed formulas utilising the 'Insert Equation' feature.*
- *High quality scanned images of hand calculations, inserted into the document.*

NO need for this in your report.

Task 1 – Prime Movers and Conditioning.

1) Discuss the operating principles of both hydraulic and pneumatic systems.

Comment on the following as a minimum:

- The differences and similarities in their operation and design.
- Expected performance and output pressures.
- Industrial sector application examples.
- Health, safety and environmental factors associated with systems and fluids.

All of these points have been researched and addressed.

Operating Principles of hydraulic systems

The basis for all hydraulics systems is expressed by Pascals law, which states, 'in a fluid at rest in a closed container, a pressure change in one part is transmitted without loss to every portion of the fluid and to the walls of the container'. (Britannica, 2023). Pascals Law can be expressed by the equation,

$$P = \frac{F}{A}$$

you are stating the fundamental principles here rather than operating principles.

In practical terms, pressure exerted on a piston within a hydraulic system produces an equal increase in pressure on another piston in the system. Using pascals formula for pressure, if the 2nd piston has an area 5 times that of the first, the force on the 2nd piston is 5 times greater- though the pressure hasn't changed. Another discovery by Pascal within fluid mechanics is that the pressure at a point in a fluid at rest is the same in all directions- 'the pressure would be the same on all planes passing through a specific point' (Britannica, 2023). ✓ *Good example.*

Operating Principles of pneumatic systems

Pneumatic answer is great as it explores typical operation setup.

With pneumatic systems, air is used to transfer pressure to the desired output within the system.

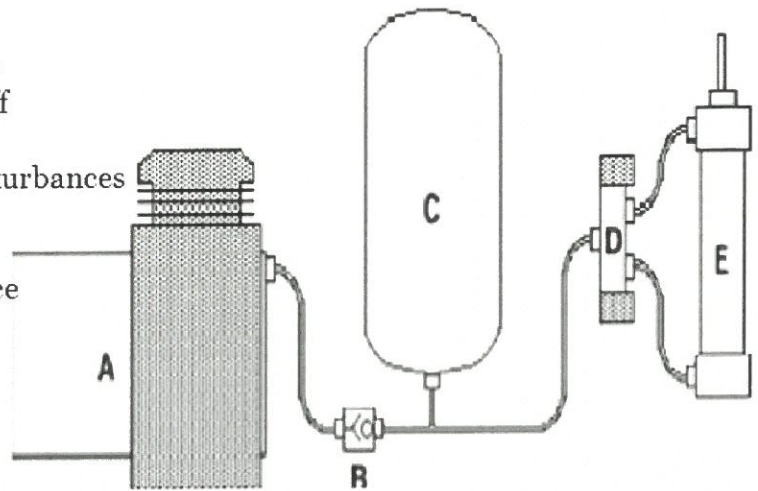
Figure 1 shows a basic pneumatic system, with a compressor, one way valve, accumulator, directional valve and actuator (Thaker, R. (2020)). The compressor pressurizes air and typically has a tank attached for storage. The valve prevents backflow and compression losses.

Accumulators are used for smooth air flow and to steady the supply for the system. The directional valve channels the air flow in the desired direction to drive the actuator. The actuator then transfers air energy into motion- such as opening and closing a control valve. ✓

** No need for double brackets.*

Basic Pneumatic System

- **A) Compressor**
 - Pressurizes Air
 - Typically attached to tank for storage
 - Often is a centralized supply for multiple devices
- **B) Check Valve**
 - One way valve
 - Prevents backflow into compressor
 - Prevents compression loss when off
- **C) Accumulator**
 - Smooth air flow and unwanted disturbances
- **D) Directional Valve**
 - Direct Air flow
 - Stores energy and reduce turbulence
 - Electrical or manual operation
- **E) Actuator**
 - Transfers air energy into motion
 - Ex. Air Chisel



Good reference to diagram.

Figure 1, source: Thaker, R. (2020) ✓

Differences and similarities between hydraulics and pneumatics

Generally, pneumatic systems are cheaper to buy components for and to operate than hydraulics, as these systems use air as a means to transmit force rather than oil mediums. The only downside of this is that pneumatic systems suffer more energy losses during the compression process. ^{+ this is key.} In terms of maintenance, pneumatic systems are typically easier to work on than hydraulics and have longer service life, due to the lower pressures involved, more simplistic components and that the equipment is less susceptible to shock damage than hydraulics. Pneumatic systems are generally available in smaller sizes than hydraulic skids, ? therefore suit a wider range of applications. Due to the incompressibility of liquids, one advantage hydraulics have over pneumatics is the ability to generate much greater force and are able to operate at far higher pressures effectively. (Primary Fluid Power, (2022)). ✓

e.g.

No need for full stop before, as reference should form part of sentence. → (Primary Fluid Power, 2022).
 ↑ Author ↑ comma ↑ Date ↑ Full Stop.

Expected performance and output pressures- a comparison

Pneumatics perform well where applications can use lower pressures to achieve their function, as gas is more compressible than liquid. Generally, these systems work well between 30 and 100 psi supply. ✓ These pressures are ideal for use with diaphragms within valve actuators, small linkages on valve positioners and so forth. ✓ Hydraulic systems work with much higher-pressure ranges, from 1500 to 5000 psi and upwards. ✓ (RS Tools. (2023)). *'The accepted international standard for maximum working pressure in the high-pressure hydraulic tools industry is 700 Bar (10,000 PSI). The criteria for establishing the maximum output force of a hydraulic cylinder at 700 Bar pressure is the size of the effective area of the cylinder bore i.e., the area to which the hydraulic fluid at a pressure of 700 Bar is being applied. Because of these simple criteria it is possible to manufacture cylinders... from 4.5 tonnes up to an excess of 1000 tonnes capacity.'* ✓ (Hi Force Hydraulic Tools. 2016). ✓

You could have taken the information held in this quote and reworded.

Industrial application examples of hydraulic systems



Common applications of hydraulics in industrial environments include lifting equipment such as cranes and jacks, ✓ see figure 2. Hydraulically actuated rams where a large amount of force is required to move a valve is another example. ✓ Power steering and braking where quick reactions and changes of state are required. ✓ Rams and presses, crushing equipment (using hydraulic fluid is very efficient in terms of power transfer for these tasks. (Miller, P. 2019). ✓

Figure 2, Source: <https://yukeneurope.com/advantages-of-using-a-hydraulic-system/> ✓

← Harvard reference.

Industrial application examples of pneumatic systems

Pneumatic systems are commonly used at sites like oil refineries and power stations to control valves via I/P transducers, positioners and spring actuation. ✓ Some positioners are digitally controlled, some have pneumatic mechanical internals. ✓ Hand tools such as nail guns, impact drivers and jack hammers can be pneumatically controlled, for ease of use and fast actuation. ✓ Pneumatics are used on assembly lines, because of the precision of these systems and low cost. ✓ See figure 3, for an example of a pneumatically controlled positioner on a fluid coupling. ✓



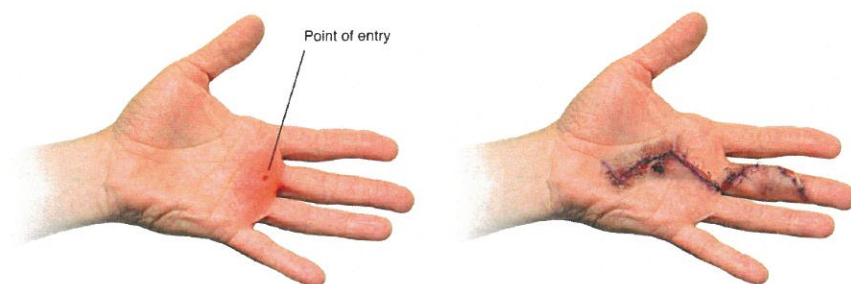
Figure 3, Source: Heather Raymond, Valero Refinery *Date?*

Health & safety considerations for both systems/ fluids

*Excellent example.
- missed opportunity to explore this further.*

Various policies and acts cover the Health and Safety aspects of working with both pneumatics and hydraulics in the UK. Some that immediately come to mind include the Health and Safety at Work Act (1974), COSHH (2002), LOLER (1998) and The Work in Compressed Air Regulations (1996). One of the most dangerous aspects of hydraulic systems is the high pressure at which they operate. Unexpected fluid injection from highly pressurised hydraulic oil can result in injuries such as that shown in *figure 4*.

Compressed air leaks also have the potential for serious injury and death. Appropriate signage and guarding should be used with machinery and equipment. Hydraulic oil should be stored appropriately.



Photographs showing the innocuous appearance of a fluid injection wound and the extent of the surgery needed to treat it.

Figure 4, source: <https://www.bunzlafety.com.au/article/179/high-pressure-fluid-injection-injuries>

2) Discuss one air compression method that could be used to supply a pneumatic process system within a temperature controlled clean room.

Include air conditioning methods appropriate to the application.

A rotary vane compressor could be used to supply a pneumatic process system for air conditioning. This type of compressor relies on two openings in a cylindrical casing, with one being suction and the other for discharge. A rotor will be positioned eccentrically in relation to the casing. Compression occurs by refrigerant flowing into the chamber, where, due to eccentric rotation, there is a reduction in volume. Some more modern examples of rotary vane compressors include the use of two rotors revolving in counter rotating directions. This compression method would be good for supplying a pneumatic process system in a temperature-controlled room due to its low cost, compact dimensions and low noise. Rotary Vane compressors generally produce less noise than scroll or large reciprocating compressors.

↳ what about operational cleanliness comparison?

Efficiency of twin rotary compressors is higher on average over a wide operating range, when compared to scroll compressors or single rotary technology. You'd typically expect to see up to 50kW cooling capacity, making these compressors suitable for commercial and industrial applications. Efficiency can be improved further when these compressors are fitted with brushless DC motors and inverters. CAREL INDUSTRIES S.p.A. (2023).

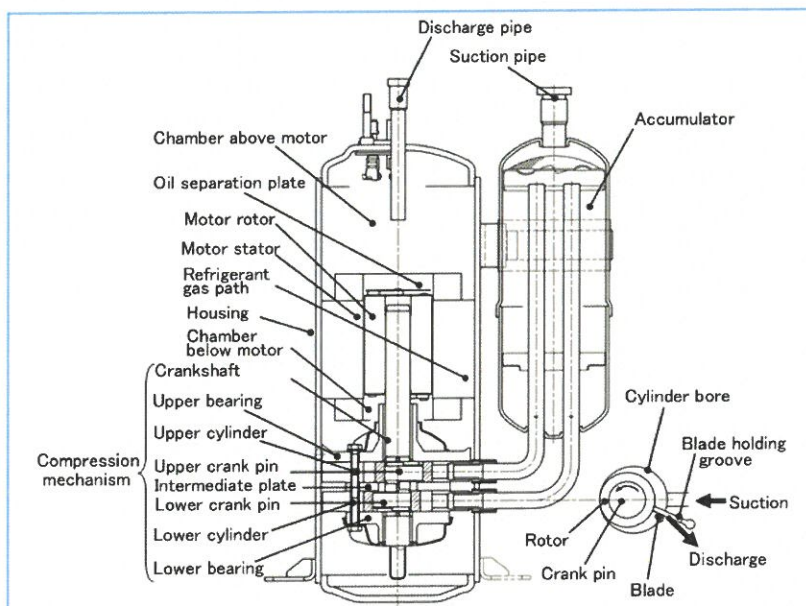


Figure 3 Internal structure of the twin rotary compressor

Figure 5 shows the components of a twin rotary compressor. Air compression in air conditioning systems typically involves using a compressor to pressurize refrigerant gas. The compressed gas releases heat as it condenses into a liquid, allowing it to absorb heat from the air. The cooled refrigerant then expands, absorbing heat from the indoor environment, and the cycle repeats. When compressors supply air to a pneumatic system in industry, air regulators, filters and non-return valves are planned into the design of the system to ensure air quality.

Figure 5,
source:

<https://www.energy.gov/energysaver/articles/energy-saver-101-home-cooling-infographic>

3) Discuss the construction and operation of two types of positive displacement pump used in hydraulic systems.

Rotary pumps- gear & lobe

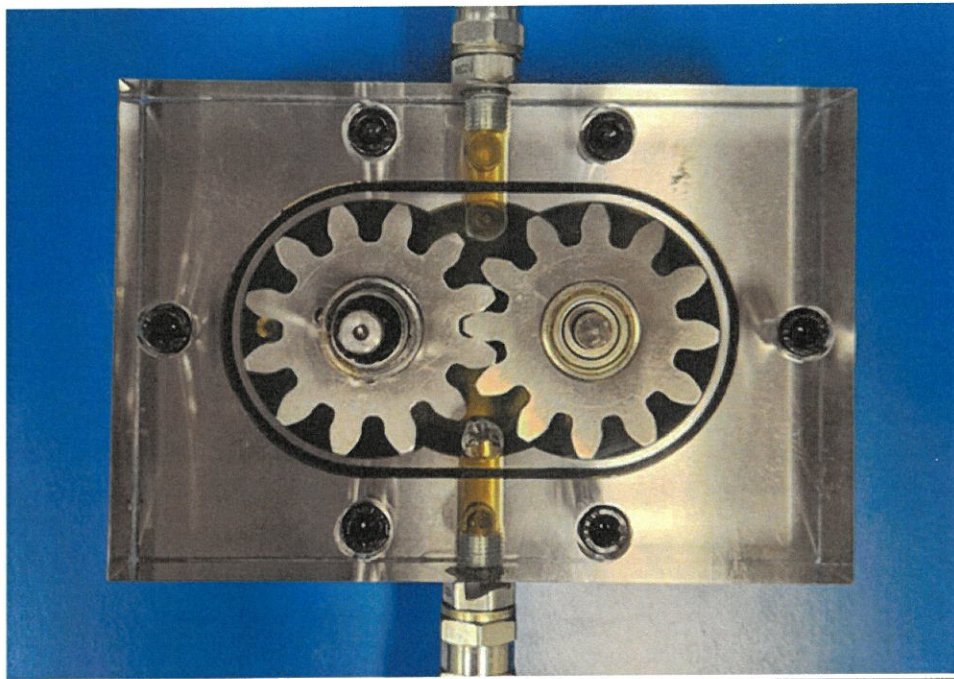


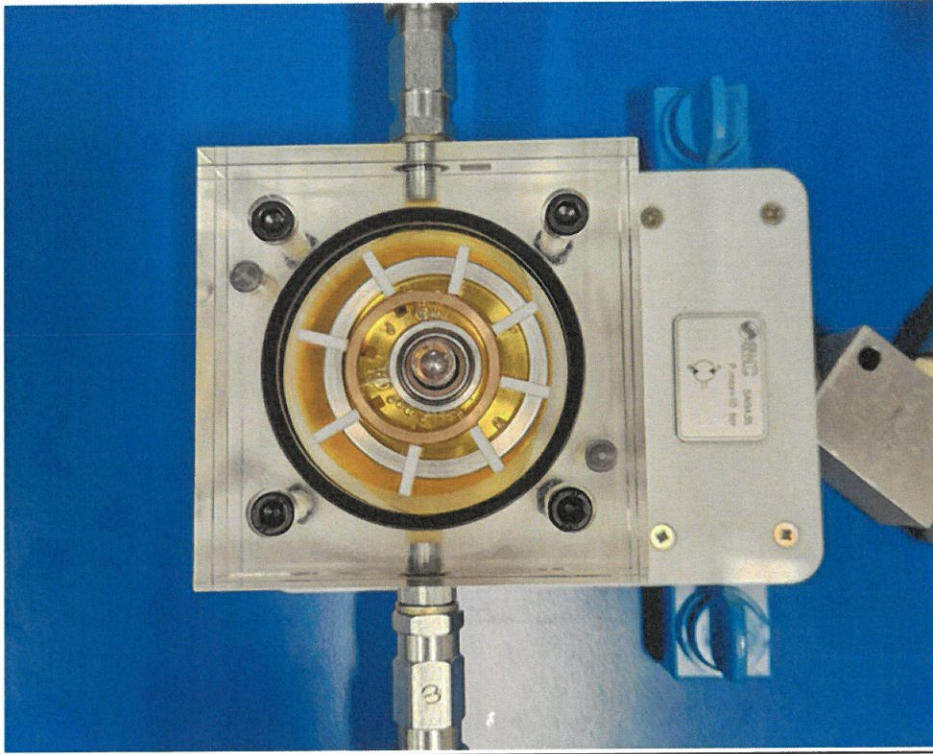
Figure 6, source: H Raymond, J Mowbray

Rotary pumps use a variety of means to generate flow, the pump in *figure 6*, utilises gears in order to do so. As the gears turn, they create a void or suction at the inlet side, causing fluid to be drawn into the pump. As a result, the fluid is carried between the gear teeth and the casing to the outlet side, where it is pushed out. The meshing and continuous un-meshing of the gears create a pumping action. The pump design is suitable for applications where a consistent fluid output is required- such as lube oil systems for engines or bearings. (Bajpai P. 2018).

A rotary pump consists of the following components,

- Housing/ casing- encloses and supports the other components, may have gaskets and seals at facings/ seats in order to maintain pressure and keep hydraulic fluid flowing in the desired direction ✓
- Gears- one would typically be the driving gear and the driven gear. They are closely meshed and rotate in opposite directions to create flow *Mesh wear is critical.*
- Shafts- The gears would be mounted on these and the shafts would then be supported by bearings ✓
- Inlet & outlet ports- The fluid enters via the inlet port and exits out of the outlet port ✓
- Drive mechanism- these pumps are typically connected to an external power source, such as an electric motor, in order to drive the gears. ✓

Vane- style pump



What efficiency, and
What pressure range
can you expect from
both pump types?



Figure 7, source: H Raymond, J Mowbray

Figure 7 shows the internals of a vane style pump. This is another form of a rotary style pump. These are commonly used on mobile hydraulic equipment and vacuum pumps. The pump in figure 7 is an unbalanced vane pump, by use of an elliptical-shaped housing with a central rotor. When these pumps consist of a pair of vanes, two inputs can be alternated by two outputs for each rotation. (Bajpai P. 2018.) This style of pump uses positive displacement to move fluid from inlet to outlet. The vanes within the pump are usually free to move in and out of the rotor slots. The vane pump will have a cam ring located inside the housing and is often elliptical in shape. These pumps are known for their smooth operation and ability to handle various viscosities. Singh K H. (2017). A typical cycle of the pump would look like this,

- Intake (suction)- As the rotor rotates, the vanes are forced outwards via centrifugal force, creating an increasing volume at the inlet end of the pump. Thus, creating a vacuum and fluid is drawn into the pump via the inlet port ✓
- Compression (discharge)- The vanes will slide back into rotor slots as they follow the contour of the cam ring. This reduces volume, causing the fluid to be compressed and hence forced out of the outlet port ✓ * →
- Continuous rotation- The movement of the rotor and vanes create a continuous pumping action. The vanes maintain contact with the cam ring, ensuring a consistent flow of fluid. ✓

* The fluid is pressurised, not compressed.

- 4) Discuss the various methods and equipment used to control the pressure within a pneumatic system and a hydraulic system.

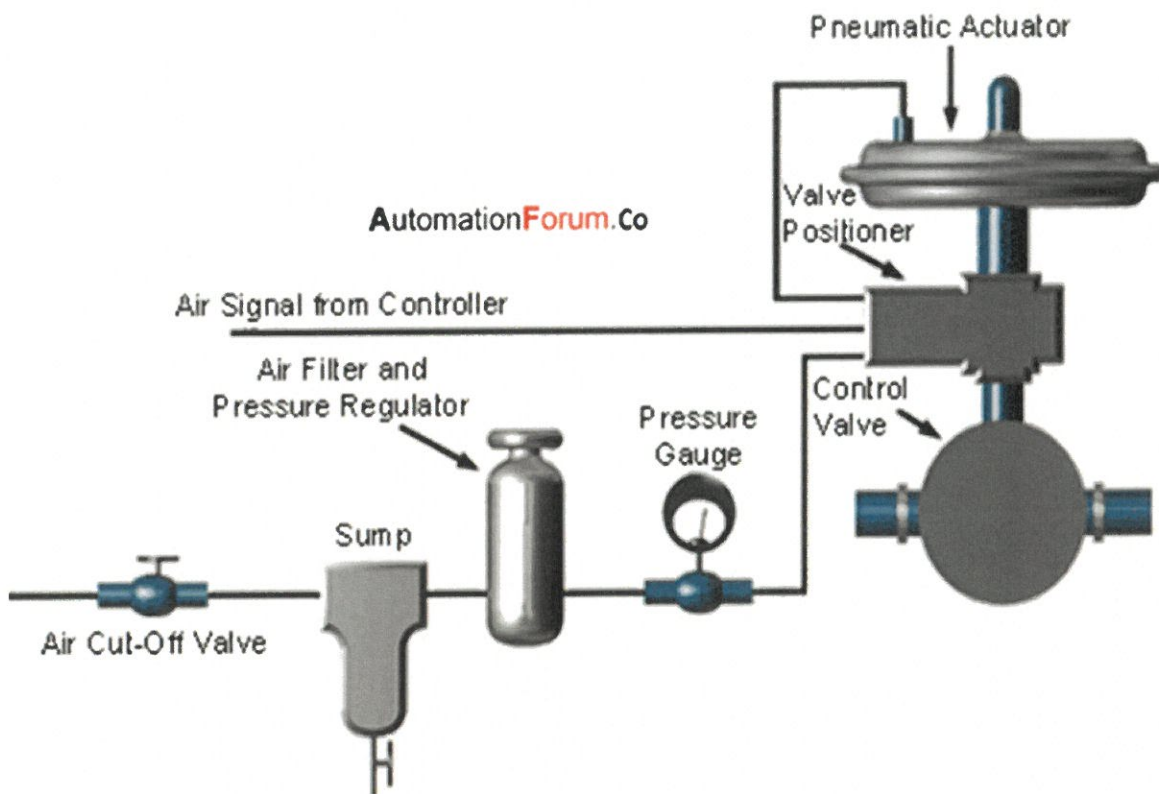


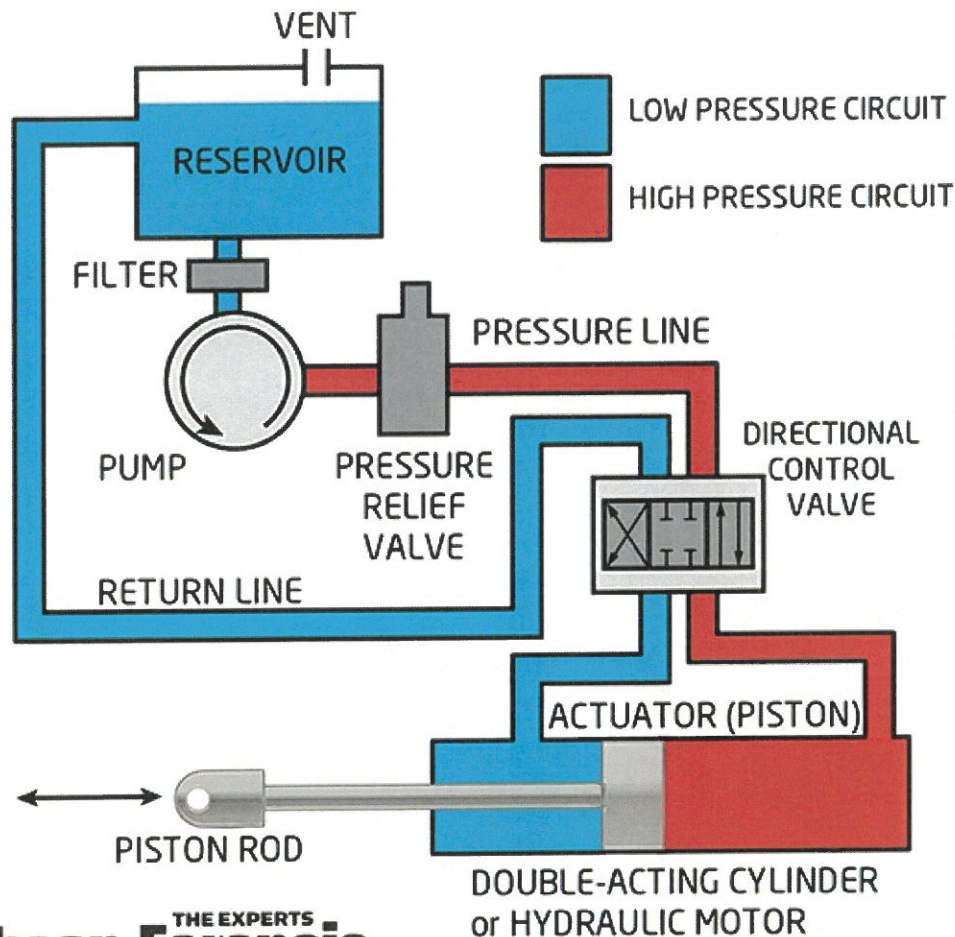
Figure 8, source: <https://blog.isa.org/common-types-of-pneumatic-valves>

Pneumatic systems typically have a set supply pressure of air, which is then regulated before being used for various applications, such as the control of a valve, see figure 8. A pressure regulator and filter will adjust its output pressure to a set level, ensuring stability and preventing excessive pressure that could damage components. A regulator typically has inlet and outlet ports, an adjustment screw that changes the output pressure and a diaphragm/ spring mechanism that changes in response to pressure. *'In essence, the diaphragm acted as a force-balancing system. An imbalance between the reference force and force generated by the outlet pressure moved the diaphragm, which actuated the valve and, in turn, restored the balance.'* Korane, K. (2021).

One way cut-off valves can be implemented to isolate instruments from the supply air when maintenance is required. Accumulation drums/ tanks can be used to store additional air supply, in case of loss of the supply. Dump valves can be used with control valves for quicker actuation when required. Positioners are typically used when valves have to operate over a range of positions, these regulate the air supply given to the actuator. Local pressure gauges can be used to monitor pressure within the system.

yes, often a range of devices are required.

Basic Hydraulic System



Robson Forensic THE EXPERTS

Figure 9, source: <https://www.robsonforensic.com/articles/hydraulics-expert-witness>

Within Hydraulic systems, pressure control is typically achieved with the use of hydraulic pressure control valves, as the per the system shown in *figure 9*. The reservoir tank is used to store the hydraulic oil used in the system and allows for fluid expansion and the release of any trapped air via a vent. The relief valve (RV) limits the hydraulic system pressure to a specific pressure to protect the pump, cylinder and other componentry. The 'Directional control valve (DCV): provides high-pressure hydraulic fluid to the desired port on the actuator or hydraulic motor with a return port for the low-pressure hydraulic fluid. DCVs control the start, stop and change in direction of the hydraulic fluid.' Green, J. (2018). In some systems, pressure reducing valves will allow high-pressure fluid from the main system to enter but reduces it to a preset lower pressure before going through the return section.

Pressure transducers can be used as sensors that monitor the pressure in the hydraulic system. The information from these sensors can be used in feedback loops to adjust the operation of various hydraulic components.

Task 2 – Calculations

Apply fluid power knowledge and relevant formulas to solve the following series of tasks that encompass the various stages which influence system pressure before reaching an actuator.

2.1 Compressor

A two-stage compressor is drawing in 25 cubic metres per minute of free air at N.T.P condition.

Determine the output flow rate based on the following instrumented values.

	Instrumented Values	
	Stage 1	Stage 2
Temperature	w	y
Pressure (Absolute)	x	z

Student	w	x	y	z
JC	40°C	510kPa	72°C	900kPa
KC	42°C	525kPa	70°C	850kPa
SD	45°C	540kPa	75°C	800kPa
JH	48°C	500kPa	68°C	1MPa
PP	39°C	555kPa	76°C	800kPa
HR	43°C	535kPa	72°C	950kPa

Please refer to *figure 10, page 14* for the calculations for this task. The final output flow rate of the 2-stage compressor, based on the values given in the *table*, is 3.14 m³/ min. ✓

2.1 Compressor

N.T.P condition air intake

$$T_1 = 20 + 273 = 293 \text{ Kelvins}$$

$$P_1 = 101.325 \text{ kPa}$$

$$V_1 = 25 \text{ m}^3/\text{min}$$

Stage 1 $T_2 (w) = 43 + 273 = 316 \text{ Kelvins}$

(2) $P_2 = 535 \text{ kPa}$

$$V_2 = ?$$

$$V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{101.325 \times 10^3 \times 25 \times 316}{293 \times 535 \times 10^3}$$

$$\underline{V_2 = 5.11 \text{ m}^3/\text{min}} \quad \checkmark$$

Stage 2 $T_3 (y) = 72 + 273 = 345 \text{ Kelvins}$

(2) $P_3 = 950 \text{ kPa}$

$$V_3 = ?$$

$$V_3 = \frac{P_2 V_2 T_3}{T_2 P_3} = \frac{535 \times 10^3 \times 5.11 \times 345}{316 \times 950 \times 10^3}$$

$$\text{output flow rate} = 3.14 \text{ m}^3/\text{min} \quad \checkmark$$

Good method.

Figure 10, calculations for task 2.1

2.2 Pipe Losses

A 20mm diameter flexible air hose is connected to the air receiver outlet, the hose is 62 metres in length.

Determine the available pressure at the end of the pipe by taking the pressure losses at steady flow into account, the flow rate is restricted to 20 cubic decimetres per second.

Also calculate the pneumatic force of the air at the end of the pipe. Supply pressure is given as z in previous task.

Refer to Figure 11 – Pressure Nomogram.

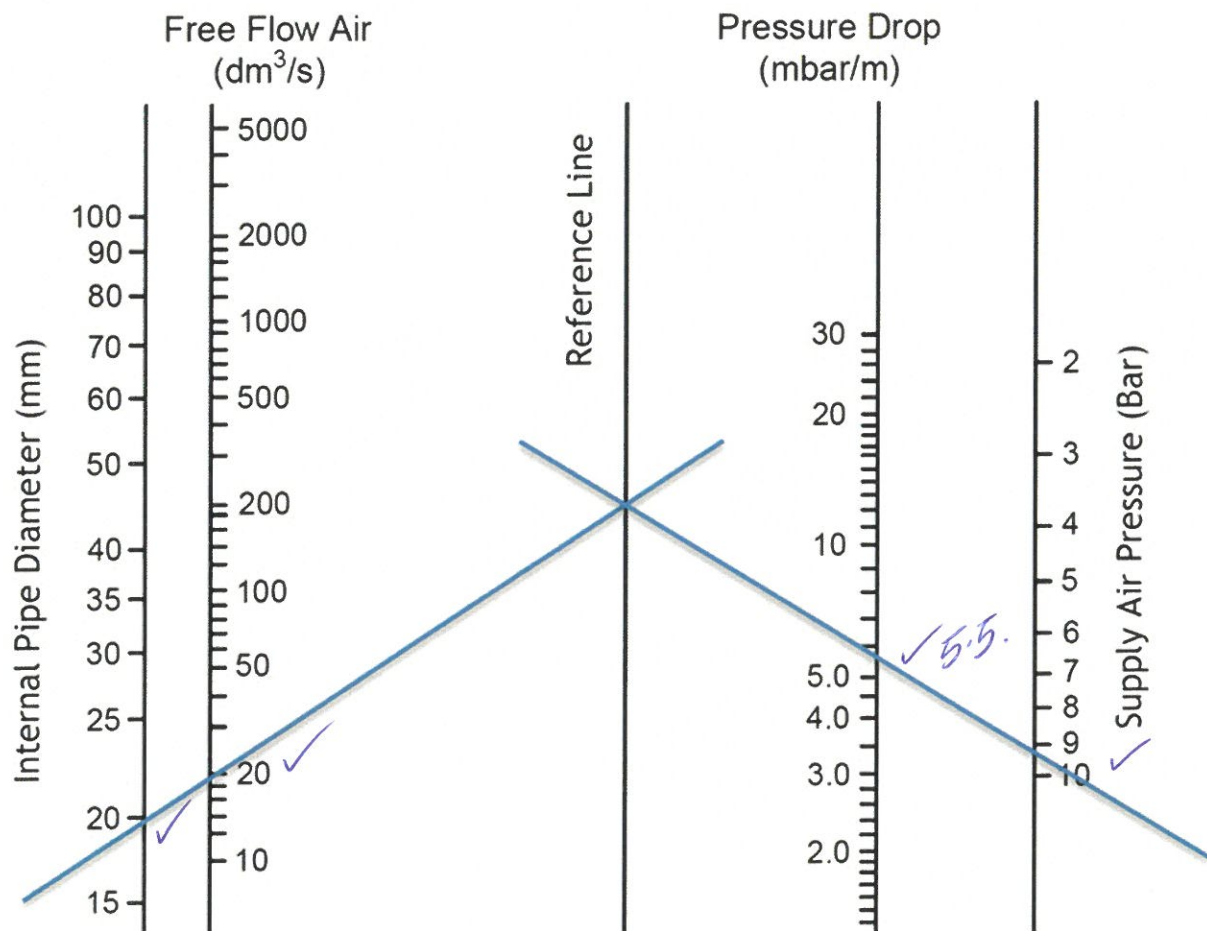


Figure 11, Pressure Nomogram

Please refer to figures 11 & 12, for the available pressure at the end of the flexible air hose is the pressure drop indicated by the nomogram, multiplied by the length of the hose- then deducted from the supply pressure. After performing calculations as per figure 12 the available pressure is 915.9 Kpa. Performing further calculations, the pneumatic force of the air at the end of the pipe was found to be 287.74 Newtons.

2.2 Pipe Losses

● 20mm diameter air hose

62m in length

Supply pressure = 950 kpa (2) = 9.5 bar

Flow rate 20 cubic decimeters

$$9.5 \text{ bar} - (5.5 \times 62) \text{ mbar} = 9.159 \text{ bar} \checkmark$$

● available pressure = 915.9 kpa

Pneumatic force of the air at the end of the pipe.

$$P = F/A$$

$$F = P \times A$$

$$F = 915.9 \times 10^3 \times \left(\frac{\pi \times 0.02^2}{4} \right)$$

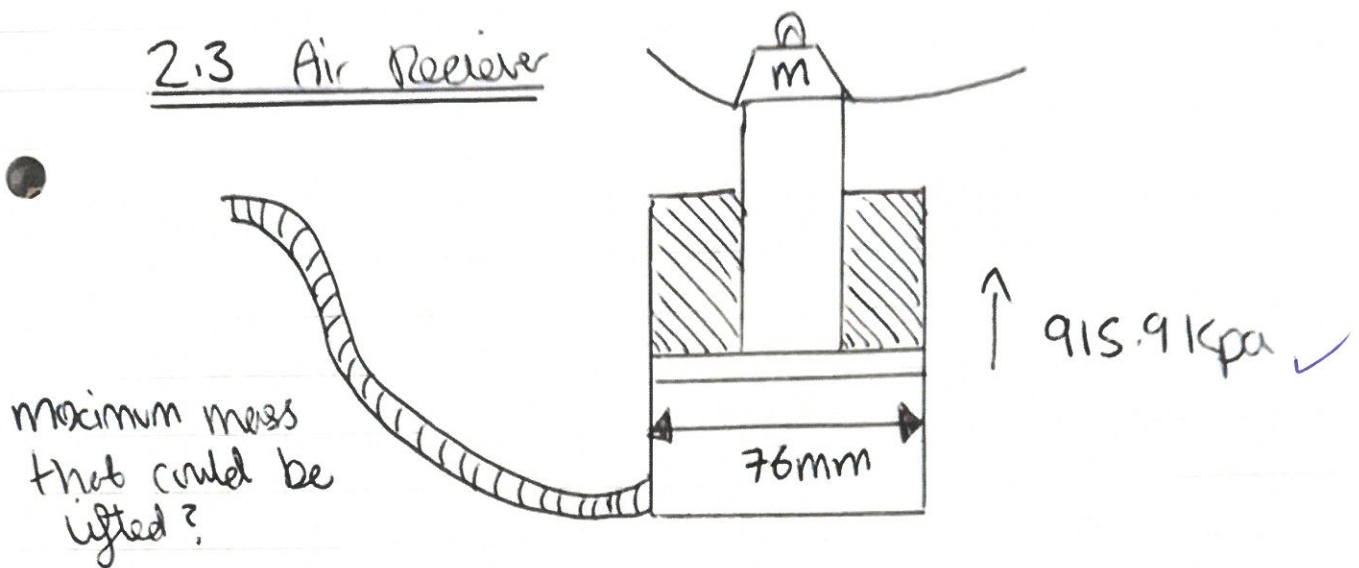
$$\underline{\underline{F = 287.74 \text{ N}}} \checkmark$$

Figure 12, 2.2 calculations

2.3 Air Receiver

The flexible pipe is connected to a single acting, vertically positioned pneumatic cylinder of 76mm internal bore diameter. Supply pressure comes from task 2.2.

Determine the maximum mass which could be lifted by this system.



$$P = F/A$$

$$F = P \times A$$

$$F = 915.9 \times 10^3 \times \left(\frac{\pi \times 0.076^2}{4} \right)$$

$$F = 4154.94 \text{ N} \quad \checkmark$$

$$F = ma$$

$$m = \frac{4154.94}{9.81}$$

$$\underline{\underline{\text{Mass} = 423.54 \text{ kg}}} \quad \checkmark$$

Figure 13, air receiver calculations

As per figure 13 it has been calculated that the maximum mass that could be lifted by this system is 423.54kg. This figure was determined by using Pascals law and rearranging the formula depending on the known variables. ✓

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✓ + Evidence of wider reading

- layout, bibliography should
come after your reference list.

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✓
*Good range of sources.
Current Harvard system used.*

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Feedback completed digitally.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills		
	30	
2. Knowledge and Understanding Skills		
	60	
3. Cognitive and Intellectual Skills	0	
4. Practical Application Skills	0	
5. Transferable Skills for Life and Professional Practice		
	10	

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)

Late Submission Penalties (tick if appropriate)

Up to 1 week late (40% Max)

Over 1 week late (0%)

%

GENERIC ASSESSMENT CRITERIA

Level 4

In accordance with the Framework for Higher Education Qualifications, at the end of Level 4 students will be expected to have demonstrated knowledge of the basic underlying concepts and principles of a subject, and an ability to evaluate and interpret these within the context of that area of study. They should be able to present, evaluate and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements in accordance with basic theories and concepts of their subject(s) of study. They will have learned how to evaluate different approaches to solving problems, and will be able to communicate the results of their study/work accurately and reliably, and with structured and coherent arguments. They will be able to undertake further training and develop new skills within a structured and managed environment and will have the qualities and transferable skills necessary for employment requiring the exercise of some personal responsibility.

Level 5	Category	FAIL 0-29%	MARGINAL FAIL 30-39%	SATISFACTORY (3 rd / Pass) 40-49%	GOOD (2.2 / Pass) 50-59%	VERY GOOD (2.1 / Merit) 60-69%	EXCELLENT (1 st / Distinction) 70-84%	EXCEPTIONAL (1 st / Distinction) 85-100%
	Engagement with literature (including reading, referencing, academic conventions and academic honesty)	Little or no evidence of reading and/or reliance on inappropriate sources. Views and findings mostly unsupported and non-authoritative. Referencing conventions used incoherently or largely absent.	Poor engagement with essential reading. No evidence of wider reading. Reliance on inappropriate sources, and/or indiscriminate use of sources. Heavily reliant on information gained through class contact. Inconsistent and weak use of referencing.	Engagement with a limited range of mostly relevant and credible sources but with some reliance on information gained through class contact. Some omissions and minor errors. Referencing conventions evident though not always applied accurately or consistently.	Engagement with an appropriate range of literature, including sources retrieved independently. Some over-reliance on texts rather than other sources. Referencing may show minor inaccuracies or inconsistencies.	Engagement with a wide range of literature, including sources retrieved independently. Selection of relevant and credible sources. Generally sound referencing, with no/very few inaccuracies or inconsistencies.	Engagement with an extensive range of relevant and credible literature. Consistently accurate application of referencing.	Engagement with literature (including reading, referencing, academic conventions and academic honesty)
	Knowledge and understanding (Knowledge of the basic underlying concepts and principles of a subject.)	Major gaps in knowledge and understanding of the basic underlying concepts and principles of the subject matter. Inclusion of irrelevant material. Substantial inaccuracies.	Gaps in knowledge of the basic underlying concepts and principles, with flawed or superficial understanding. Some significant inaccuracies and/or irrelevant material.	Limited knowledge and understanding of the basic underlying concepts and principles within the subject area. Some elements may be missing.	Knowledge of the basic underlying concepts and principles is accurate with a good understanding of the field of study but lacks depth and/or breadth.	Competent knowledge of the basic underlying concepts and principles. Exhibits very good understanding.	Excellent knowledge and understanding of the basic underlying concepts of the subject.	Exceptional, detailed knowledge and understanding of the basic underlying concepts and principles

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Cognitive and intellectual skills (Evaluate underlying concepts and principles of a subject and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements.)		Wholly or almost wholly descriptive work. Little or no evaluation of the underlying concepts and principles. Failure to develop arguments, leading to illogical or invalid judgements. Minimal or no use of evidence to back up views.	Largely descriptive work, with superficial evaluation of the underlying concepts and principles. Weak interpretation of data, flawed development of arguments and judgements. Information accepted uncritically, uses generalised statements made with scant evidence and unsubstantiated opinions. Ideas sometimes illogical and contradictory.	Limited attempt at evaluation of the underlying concepts and principles, tending towards description. Can interpret qualitative and quantitative data but with some errors. Some evidence to support emerging arguments and judgements but these may be underdeveloped or with a little inconsistency / misinterpretation.	Good evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data, with minor errors. An emerging ability to use evidence to support the argument. Mostly valid logical judgements.	Sound evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data accurately. Ability to devise arguments using evidence to make mostly appropriate and valid judgements.	Excellent evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data with some insight. Excellent ability to devise arguments using evidence and make appropriate and valid judgements.	Exceptional evaluation of the underlying concepts and principles based evidence. Outstanding interpretation of qualitative and quantitative data. Exceptional ability to devise arguments using evidence and make wholly appropriate and valid judgements.
	Practical skills (Different approaches to solving problems in particular contexts.)	Limited or no use of taught, basic methods, materials, tools and/or techniques. Little or no appreciation of the context of the application. Very weak evidence of different approaches to problem-solving in particular contexts.	Rudimentary application of taught, basic methods, materials, tools and/or techniques but without consideration and competence. Flawed appreciation of the context of the application. Weak evidence of different approaches to problem-solving in particular contexts.	An adequate awareness and mostly appropriate application of basic methods, materials, tools and/or techniques. Clear appreciation of the context of the application. Good evidence of different approaches to problem-solving in particular contexts and proposes mostly appropriate solutions.	A good and appropriate application of basic methods, materials, tools and/or techniques. Clear appreciation of the context of the application. Good evidence of different approaches to problem-solving in particular contexts and proposes mostly appropriate solutions.	A very good application of a range of basic methods, materials, tools and/or techniques. Very good consideration of the context of the application. Very good evidence of different approaches to problem-solving in particular contexts and proposes appropriate solutions.	An advanced application of a range of taught, basic methods, materials, tools and/or techniques. The context of the application is well considered, and insightful. Excellent evidence of different approaches to problem-solving in particular contexts and proposes appropriate solutions.	Exceptional levels of application and deployment skills in particular practical contexts. Outstanding identification of problems in particular contexts and formulation of wholly appropriate, thoughtful solutions / different approaches.
Transferable skills for life and professional practice (Communicate the results of their		Work is poorly structured, disorganised, inaccurate and/or confusingly expressed. Very weak use of	Work is poorly presented in a disjointed manner. It is loosely, and at times incoherently, structured, with information and ideas	Mostly ordered presentation and structure in which relevant ideas / concepts are reasonably expressed. Work may	Mostly coherent, organised and accurate work, in a suitable structure and is for the most part clearly expressed. Can	Work is accurate, coherent, fluent, well-structured and organised. Can work effectively and/or independently as part of a team,	Work is coherent, very fluent and is presented professionally. Can work effectively independently and/or as part of a	Work is accurate, exceptionally coherent, very fluent and presented well. Can work effectively and/or independently as part of a team,

Level 5	FAIL	MARGINAL FAIL	SATISFACTORY (3 rd / Pass)	GOOD (2.2 / Pass)	VERY GOOD (2.1 / Merit)	EXCELLENT (1 st / Distinction)	EXCEPTIONAL (1 st / Distinction)
Category	0-29%	30-39%	40-49%	50-59%	60-69%	70-84%	85-100%
study/work accurately and reliably, and with structured and coherent arguments; the qualities needed for employment requiring the exercise of some personal responsibility within a structured and managed environment.)	language and/or very inappropriate style. Failure to work effectively individual or as part of a group. Little or no evidence of the skills for employment requiring the exercise of some personal responsibility.	often poorly expressed. Weak use of language and/or inappropriate style. Flawed approach to individual or group work, meeting only partial obligations to others. Limited evidence of the skills for employment requiring the exercise of some personal responsibility.	lack coherence and/or accuracy in places. Can work as part of a group, meeting most obligations to others but perhaps with limited involvement in group activities. Demonstrates the basic skills for employment requiring the exercise of some personal responsibility.	work effectively independently and/or as part of a team, with clear contribution to group activities. Demonstrates the skills for employment requiring the exercise of some personal responsibility, with some areas of minor weakness.	with very good contribution to group activities. Demonstrates very good skills for employment requiring the exercise of some personal responsibility, with just occasional minor weakness.	team, with an excellent contribution to group activities. Demonstrates excellent skills for employment requiring the exercise of some personal responsibility with an appetite for further development.	with an exceptional contribution to group activities. Demonstrates exceptional skills for employment requiring the exercise of some personal responsibility with an appetite for further development.