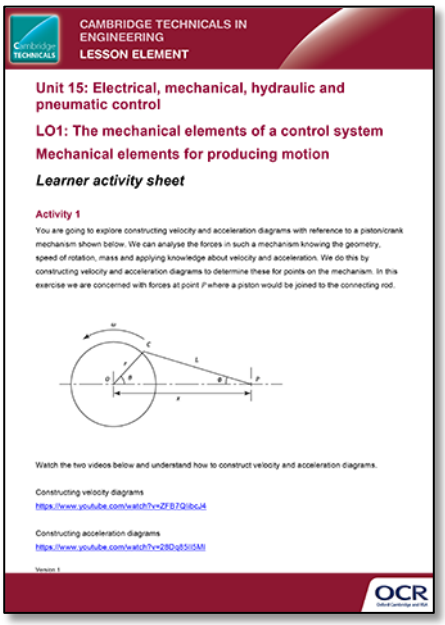
Unit 15: Electrical, mechanical, hydraulic and pneumatic control

LO1: The mechanical elements of a control system

Mechanical elements for producing motion

Instructions and answers for teachers

These instructions should accompany the OCR resource 'Mechanical elements for producing motion' *activity which supports Cambridge Technicals in Engineering Level 3.*


CAMBRIDGE TECHNICALS IN ENGINEERING
LESSON ELEMENT

Unit 15: Electrical, mechanical, hydraulic and pneumatic control

LO1: The mechanical elements of a control system

Mechanical elements for producing motion

Learner activity sheet

Activity 1

You are going to explore constructing velocity and acceleration diagrams with reference to a piston/crank mechanism shown below. We can analyse the forces in such a mechanism knowing the geometry, speed of rotation, mass and applying knowledge about velocity and acceleration. We do this by constructing velocity and acceleration diagrams to determine these for points on the mechanism. In this exercise we are concerned with forces at point P where a piston would be joined to the connecting rod.

Watch the two videos below and understand how to construct velocity and acceleration diagrams.

Constructing velocity diagrams

https://www.youtube.com/watch?v=ZFB7QIbcJ4

Constructing acceleration diagrams

https://www.youtube.com/watch?v=28OqB5II5AI

Version 1

OCR

The Activity:

This activity offers an opportunity for English skills development.

This activity offers an opportunity for maths skills development.

Suggested timings:

Activity 1

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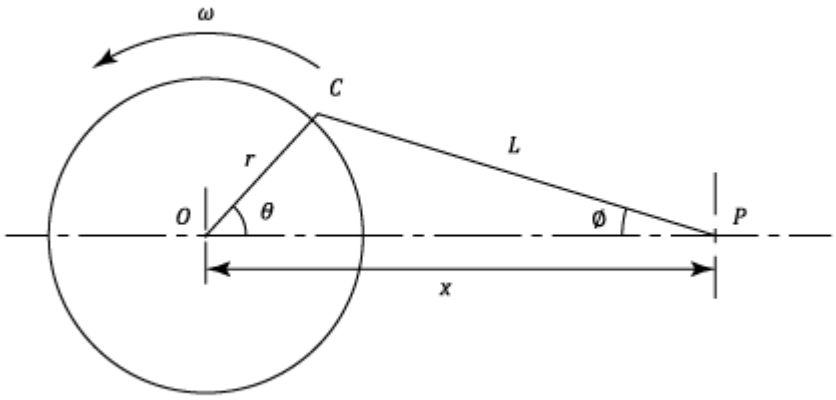

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https://www.youtube.com/watch?v=28Dq85II5MI

If the crankshaft/connecting rod arrangement above has a crank radius r of 150mm and a connecting rod length l of 600mm, what is the velocity and acceleration of the piston when the crank is at an angle θ of 60° and the engine is rotating at 47.75rpm?

Construct velocity and acceleration diagrams to determine this.

Notes:

Angular velocity is 5 rad/s.

$V_{CrelO} = \omega \times r = 5 \times 0.15 = 0.75$m/s

The velocity diagram should be a triangle and from this the velocities of the points are determined. Diagrams should be scaled to an appropriate scale (say 100mm = 1m/s).

v_{CrelP} is scaled from drawing = 0.384m/s

v_{PrelO} is the velocity of the piston, again scaled from drawing = 0.733m/s

A table can be constructed for the acceleration diagram as below

Link	velocity (m/s)	Centripedal acceleration (m/s^2)	Tangential acceleration (m/s^2)
CrelO	0.75	3.75	0
PrelC	0.384	0.246	?

Centripedal acceleration = v^2/r

The velocity diagram should have four sides and the resultant acceleration of the piston at point P can be scaled as 1.41m/s^2.

Activity 2

If the mass of the piston, gudgeon pin and reciprocating portion of the connecting rod is 650grammes, what is the force acting on the small end bearing at point P?

At what point in the crank cycle (angle θ) do you think this force would be greatest? Draw force and acceleration diagrams for this angle. Compare them with other learners to see how they compare.

Can you identify from this what are the limiting performance factors of a mechanism of this type?

Notes:

From $F = m \times a$ the force $F_P = 0.65 \times 1.41 = 0.92N$

The maximum forces would be greatest where there is a maximum change in acceleration.

Learners should compare different values for different crank angles.

Learners should also observe that the forces exerted are low because the speed of rotation is low.