

Unit 3: Principles of Mechanical Engineering

LO1: Understand systems of forces and types of loading on mechanical components

Equilibrium of a rigid body

Instructions and answers for teachers

These instructions should accompany the OCR resource 'Understand systems of forces and types of loading on mechanical components – Equilibrium of a rigid body' activity which supports Cambridge Technicals in Engineering Level 3.

The thumbnail shows the following content:

- Unit 3: Principles of Mechanical Engineering
- LO1: Understand systems of forces and types of loading on mechanical components
- Equilibrium of a rigid body
- Learner activity sheet
- Activity 1
- A uniform square plate (ABCD) 2m x 2m has a mass of 10kg. It is suspended from corner A and held in a horizontal position by a horizontal force acting at point C and shown in the fig. below.
- Diagram of a square plate ABCD with forces: F_1 at A, F_2 at C, and F_{load} at the center.
- Taking $g = 10 \text{ m/s}^2$ results in the weight of 100N, as shown.
- Using the same approach as the example above, work out the unknown values in the situation below:
- Diagram of a rectangular plate ABCD with forces: F at A, P at D, and Q at C.
- The diagram above shows a rectangular plate ABCD, with sides AD/BC of 2m, and AB/DC of 1m. It is held in equilibrium by three forces, as shown in the diagram. If the mass of the plate is 50kg find the values of F , P and Q .

The Activity:

This lesson element assumes that learners are able to find the equilibrant of a set of co-linear forces, and extends this to find forces needed to maintain the equilibrium of a rigid body.



This activity offers an opportunity for English skills development.



This activity offers an opportunity for maths skills development.

Suggested timings:

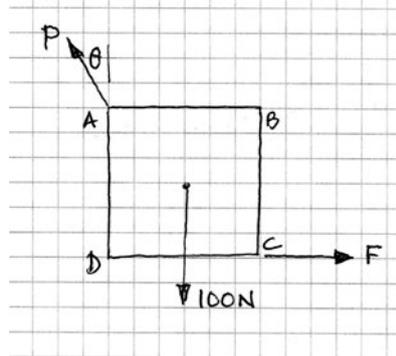
Activity 1 30 minutes

Activity 2 1+ hours

Activity 1

The lesson is a worked example of a rigid body problem.

A uniform square plate (ABCD) $2\text{m} \times 2\text{m}$ has a mass of 10kg . It is suspended from corner A and held in a horizontal position by a horizontal force acting at point C and shown in the fig. below.



Taking $g = 10 \text{ m/s}^2$ results in the weight of 100N , as shown.

It is important that learners understand that there are three unknown values (P , F and θ) that must be found to fully analyse the problem. To do this three equilibrium conditions are needed.

Resolving horizontal forces gives ($R \rightarrow +$)

$$F - P \times \sin\theta = 0 \quad \text{equ 1}$$

Resolving vertical forces gives ($R \uparrow +$)

$$P \times \cos\theta - 100 = 0 \quad \text{equ 2}$$

The third equilibrium condition comes from rotational equilibrium by taking moments about a point on the diagram. It is useful for learners to think about which point should be used to make the equation as simple as possible. For this example the most appropriate point would be A, as it eliminates 2 of the unknown values (P and θ) so the third value (F) can be found directly.

Taking moments about A (M clockwise $+$)

$$100 \times 1 - F \times 2 = 0 \quad \text{equ 3}$$

In principle there are now three equations to be solved simultaneously to find the three unknown values.

This produces values of $F = 50\text{N}$, $P = 111.8\text{N}$ and $\theta = 26.5^\circ$.

A similar example is set for learners in the learner activity task 1.

Solution to learner activity one.

Resolving forces vertically ($\uparrow +ve$)

$$P\cos\theta + F - 500 = 0 \quad (1)$$

Resolving forces horizontally ($\rightarrow +ve$)

$$F/2 - P\sin\theta = 0 \quad (2)$$

Take moments about point (anticlockwise +ve)

$$F \times 2 + F/2 \times 1 - 500 \times 1 = 0 \quad (3)$$

Equation (3) gives

$$2.5F = 500$$

$$F = 200 \text{ N}$$

Substitution for F in equation (1) gives

$$P\cos\theta = 300$$

Substitution for F in equation (2) gives

$$P\sin\theta = 100$$

So

$$\tan\theta = 100/300$$

$$\theta = 18.4^\circ$$

and

$$P = 316.2 \text{ N}$$

Activity 2

This worked example should be reinforced by several questions of a similar or equivalent type. The topic can be revisited in later sections of the unit (especially LO2).



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