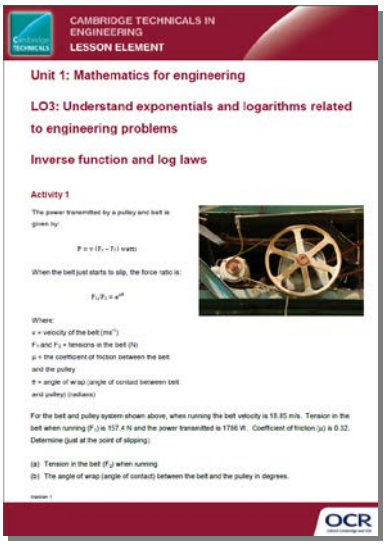
Unit 1: Mathematics for engineering

LO3: Understand exponentials and logarithms related to engineering problems

Inverse function and log laws

Instructions and answers for teachers

These instructions should accompany the OCR resource: 'Inverse function and log laws' *activity which supports OCR Level 3 Cambridge Technicals in Engineering.*


CAMBRIDGE TECHNICALS IN ENGINEERING
LESSON ELEMENT

Unit 1: Mathematics for engineering

LO3: Understand exponentials and logarithms related to engineering problems

Inverse function and log laws

Activity 1

The power transmitted by a pulley and belt is given by:

$P = v(T_1 - T_2)$ watts

When the belt just starts to slip, the force ratio is:

$T_1/T_2 = e^{\mu\theta}$

Where:
v = velocity of the belt (ms^{-1})
T_1 and T_2 = tensions in the belt (N)
μ = the coefficient of friction between the belt and the pulley
θ = angle of wrap (angle of contact between belt and pulley) (radians)

For the belt and pulley system shown above, when running the belt velocity is 18.85 m/s. Tension in the belt when running (F_1) is 157.4 N and the power transmitted is 1796 W. Coefficient of friction (μ) is 0.32. Determine (just at the point of slipping):

(a) Tension in the belt (F_2) when running
(b) The angle of wrap (angle of contact) between the belt and the pulley in degrees.

OCR

The Activity:

These activities are about a belt and pulley.

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This activity offers an opportunity for English skills development.

This activity offers an opportunity for maths skills development.

Suggested timings:

1 hour

Version 1

Activity 1

The problem in Activity 1 is about power being transmitted by a belt and a pulley. The system works on the principle of force being transmitted through friction between the belt and the pulley. It relies on there being a tight and a slack side to the belt (tensions in each side of the belt).

Teachers could develop similar problems for learners to solve. Solution to the problem given in the learner activity is shown below.

Solution

$P - v(F_1 - F_2)$ watts

Begin by finding F_2...

$1786 = 18.85\ (157.4 - F_2)$

$(1786 / 18.85) - 157.4 = -F_2$

$\therefore F_2 = 62.7$ N **(solution to part a)**

Insert values into formula $F1/F2 = e^{\mu\theta}$

$157.4/62.7 = e^{\mu\theta}$ where $\mu = 0.32$ and $\theta =$ unknown angle

Take natural logs (ln) of both sides

$\ln (157.4/62.7) = \ln (e^{\mu\theta})$

$\ln (157.4/62.7) = \mu\theta$

$0.92 = \mu\theta$

$\therefore \theta = 0.92/0.32 = 2.88$ radians

Convert answer to degrees

$\theta = (180.\ 2.88)/\pi = 164.7°$ **(solution to part b)**

Activity 2

Activity 2 presents a problem relating to charging of a capacitor. Again, teachers might wish to develop similar problems. Solution to the problem given in the learner activity is shown below.

Solution

Using the formula $V_C = V_S\ (1 - e^{-t/RC})$

Insert known values:

$7.93 = 9(1 - e^{-t/RC})$

$(7.93/9) = (1 - e^{-t/RC})$

$(7.93/9) = - e^{-t/RC}$

$-0.12 = - e^{-t/RC}$

$\therefore\ 0.12 = e^{-t/RC}$ (multiplying through by -1)

Take natural logs (ln) of both sides

$\ln (0.12) = \ln(e^{-t/RC})$

$-2.12 = -t/RC$

Insert values for R and t, and multiply through by -1

$2.12 = 100\ /\ (C \times 470x10^3)$

Rearrange for C

$C = 100/ (2.12 \times 470 \times 10^{3})$

$C = 1.00 \times 10^{4}$ or 100×10^{-6} or 100 μF