Pearson
BTEC

Pearson BTEC Set Assignment Brief

Pearson BTEC International Level 3 Diploma in Engineering

Unit 1: Mechanical Principles

Student Name

Assessment date: 15/12/2020

ACTIVITY 1

1. The total time spent machining components is represented by the equation of a straight line:

Total time $t = 6n - 2$

where n is the number of components and t is the total time in minutes.

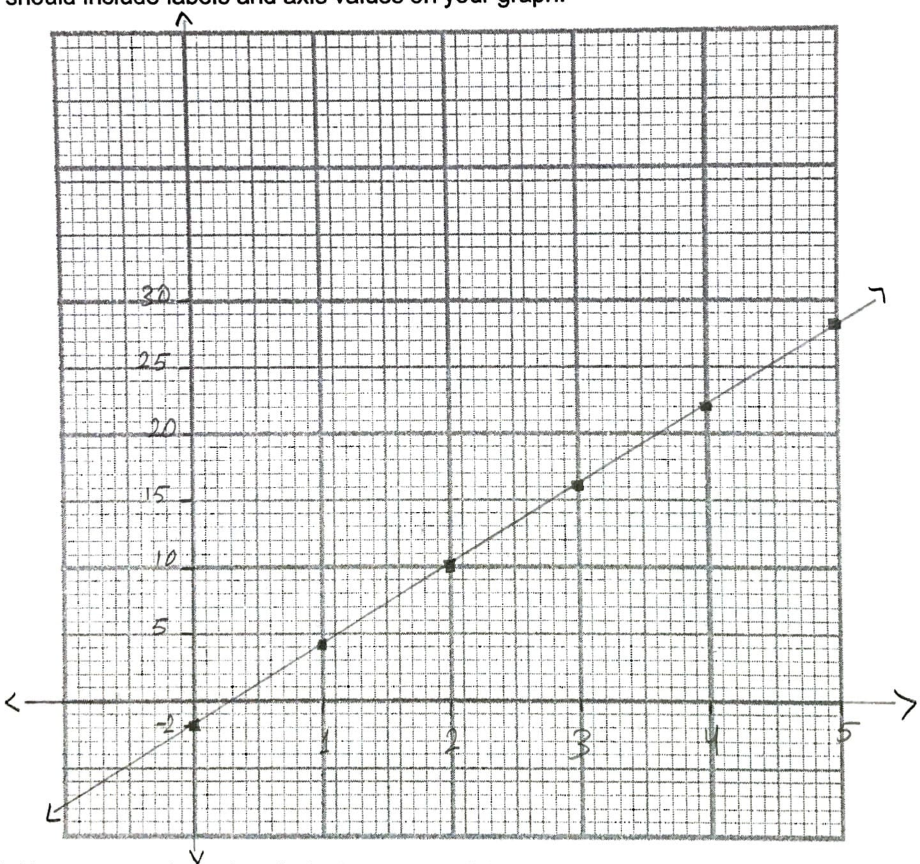
(a) Complete the table for the time taken to manufacture 5 components.

$t = 6n - 2$

$n = 0 \rightarrow t = -2$, $n = 1 \rightarrow t = 4$, $n = 2 \rightarrow t = 10$, $n = 3 \rightarrow t = 16$, $n = 4 \rightarrow t = 22$, $n = 5 \rightarrow t = 28$

Number of components, n	0	1	2	3	4	5
Time taken, t (min)	-2	4	10	16	22	28

(b) Draw a straight-line graph to represent the time spent machining the components. You should include labels and axis values on your graph.



(c) Use your graph to identify the intercepts of the n and t axes.

the intercepts of

$t \Rightarrow (0, -2)$

$n \Rightarrow (\frac{1}{3}, 0)$

2. The diagram shows a finished engineered component machined from a square piece of aluminium with holes drilled through it. The drilled holes have the shape of a cylinder.

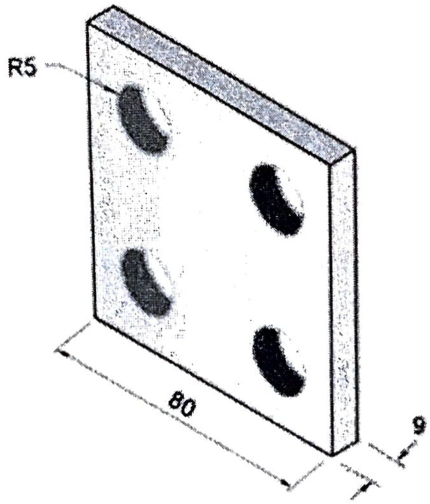


Diagram not to scale and all dimensions in mm

(a) Calculate the volume of the component before any holes are drilled.

$V_{ratbolck}$ = Length * Width * hight

= 9 * 80 * 80 = 57 600 mm^3

(b) Calculate the volume of metal removed when machining one hole.

$V_{cylinder} = \pi r^2 h$

$= 3.14 * 5^2 * 9 = 706.5\ mm^3$

(c) Calculate the volume of the finished component.

$= V_{ratblock} - V_{4\,cylinder}$

$= (57600) - (4 * 706.5)$

$= 54774\ mm^3$

The cost of machining similar components is represented by the formula:

Cost ($) = $3x^2 + 4x$

where x is the number of holes to be drilled.

(d) Calculate, by factorisation, the number of holes that would need to be drilled if the total component cost is $20.

By using this formula => $X = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$

$3x^2+4x-20=0$, $b=4$, $a=3$, $c=-20$

$X = \frac{-4 \pm \sqrt{4^2-4*3*-20}}{2*3} = \frac{-4 \pm \sqrt{256}}{6} = \frac{-4 \pm 16}{6}$

$\boxed{X_1 = 2}$ => ✓ num. of holes need to be drilled

$X_2 = -3$

3. A rope is attached to a drum as shown in the diagram.

Assume that the rope is wound around the drum and it is always in contact with the surface of the drum.

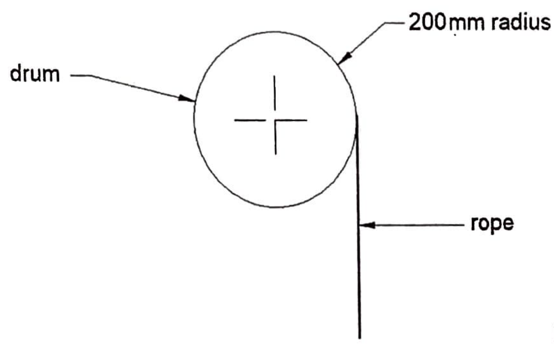


Diagram not to scale

The drum rotates through 7.5 revolutions.

(a) Calculate the total angle through which the drum rotates in degrees.

$7.5 * 360° = 2700°$

(b) Convert the total angle to radian measure.

$\frac{2700° * 2\pi}{360°} = 15\pi = 15 * \frac{22}{7}$

≈ 47 rad

(c) Calculate the length of rope that has been wound on to the drum.

Circumference $= 2\pi r = 2 * 3.14 * 200 \approx 1256$ mm

Length of rope $= 7.5 * 256$
$= 9420$ mm

4. The diagram shows a structure that is used to support a cable. The support is bolted on to the top of a wall at point F and supports a cable from point H.

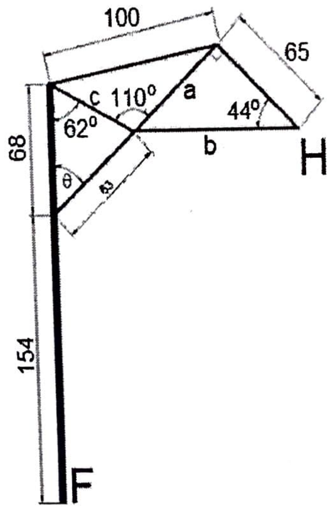


Diagram not to scale and all dimensions in mm

(a) Calculate the length of side 'a'.

$\tan 44° = \frac{a}{65}$ => $a = 65 \times \tan 44 \approx 62$ mm

(b) Calculate the angle θ.

$\theta = 180° - ((180° - 110°) + 62°) = 48°$

(c) Calculate the length of side 'c'.

$\frac{c}{\sin 70°} = \frac{63}{\sin 62°}$

$c = \frac{63 \times \sin 70°}{\sin 62°} \approx 67$ mm

(d) Calculate the height of point 'H' compared to point 'F'.

$= 154 + (63 \times \cos 48°)$

≈ 196 mm

ACTIVITY 2

1. The diagram shows a beam that is supported by two cables attached to roof structure of a warehouse.

Ignore the mass of the beam. Assume that the tension force in the cables is equal and opposite to the reaction forces at each of the supports.

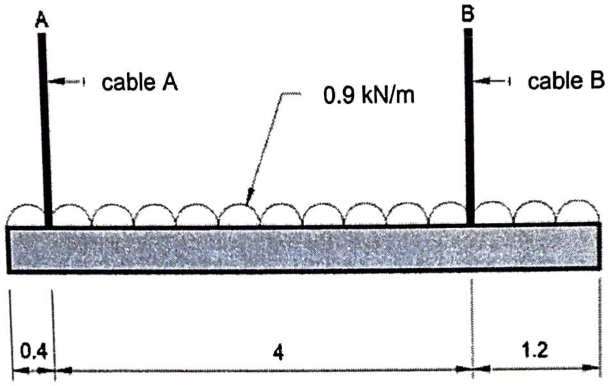


Diagram not to scale and all dimensions in metres

(a) Calculate the total load due to the UDL.

$= 0.9 * (0.4 + 4 + 1.2)$

$= 5.04$ kN

(b) Calculate the tension force in cable A. $\Sigma M_B = 0$

$4T_A = 5.04 * (2.8 - 1.2)$

$\frac{4T_A}{4} = \frac{8.064}{4}$

$T_A = 2.016$ kN

Cable A has a diameter of 5 mm and an original length of 1.5 m.

(c) Calculate the direct stress in cable A to 3 significant figures (SF).

$$\sigma = \frac{T_A}{A} = \frac{2.016 * 10^3}{\frac{3.14}{4} * 25 * 10^{-6}} \approx 102 * 10^6 \ Pa$$

$\boxed{A = 3.14 * r^2}$

The modulus of elasticity of the cable is 190 GPa.

(d) Calculate how much the cable will stretch due to the loading of the beam.

$$E = \frac{\sigma}{\varepsilon}$$

$$E = \frac{\sigma}{\frac{\Delta l}{l}} \Rightarrow \Delta l = \frac{\sigma}{E} \cdot l = \frac{102 * 10^6 * 1.5}{190 * 10^9}$$

$$\Delta l \approx 8.05 * 10^{-4} \ m$$

2. The diagram shows an image of a gradually tapering pipe. The inlet velocity of an unknown fluid is 8 m/s.

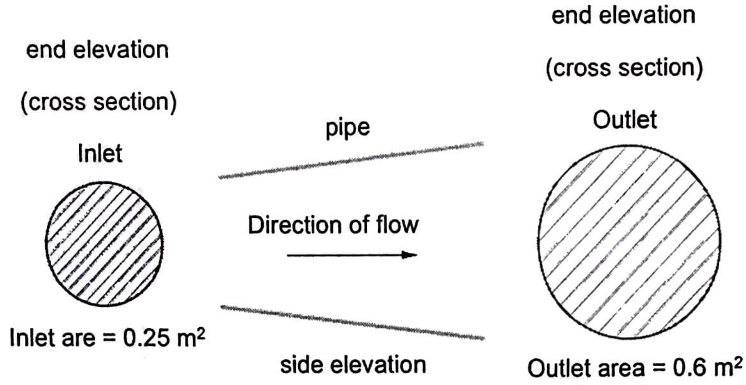


Diagram not to scale

The pipe runs full with an unknown incompressible fluid.

(a) Calculate the volumetric flow rate of the unknown fluid at the inlet.

$\dot{V} = A_1 V_1$

$= 0.25 \times 8 = 2 m^3/s$

(b) Calculate the outlet velocity of the fluid.

$A_1 V_1 = A_2 V_2$

$2 = 0.6 V_2$

$V_2 = \frac{2}{0.6} \approx 3.3 m/s$

The unknown fluid pours into the tank until it is full. One side of the tank is hinged, so the tank can be emptied quickly.

The tank has a depth of 4m.

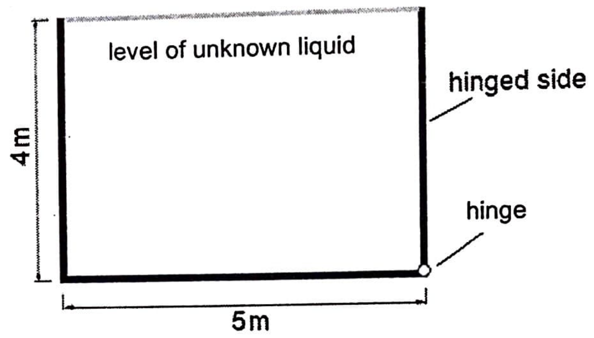


Diagram not to scale

The density of the unknown fluid is 1137kg/m³.

(c) Calculate the overturning moment acting on the hinged side.

$A = 4 * 4 = 16 \ m^2$

Overturning moment $= F \frac{h}{3}$

$= \rho g A \frac{h}{2} \frac{h}{3} = 1137 * 9.81 * 16 * \frac{4}{2} * \frac{4}{3}$

$= 475902.72 \ Nm$

3. The diagram shows a railway engine travelling towards a stationary truck.

Assume the track is frictionless.

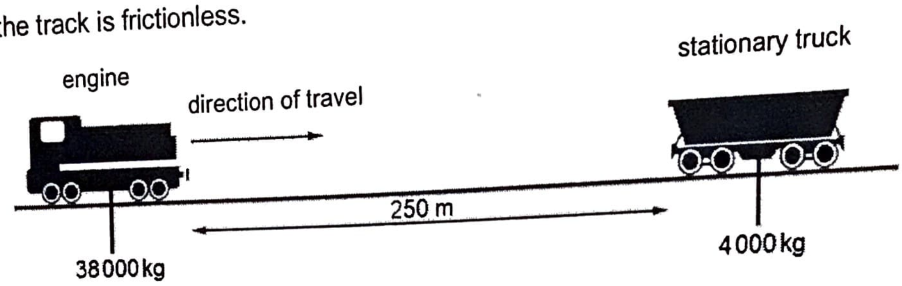


Diagram not to scale

The engine has an initial velocity of 12 m/s.

The engine decelerates at a constant rate of 0.28 m/s² over a distance of 250m.

(a) Calculate the velocity of the engine after it has travelled 250m.

$V^2 = u^2 + 2as$

$= 12^2 + 2 \times -0.28 \times 250$

$V^2 = 144 - 140 \Rightarrow \sqrt{V^2} = \sqrt{4} = \boxed{V = 2 \text{ m/s}}$

The engine collides and couples to the stationary truck and continues moving.

(b) Calculate the momentum of the engine just before it collides with the truck.

$P_E = mv = 38000 \times 2 = 76000 \text{ Ns}$

(c) Calculate the velocity of the truck and engine just after the collision.

$P_E = P_f \Rightarrow \frac{76000}{4000} = \frac{4000 V_f}{4000}$

$V_f = 19 \text{ m/s}$

(d) Calculate the kinetic energy of the combined truck and engine.

Kinetic energy $= \frac{1}{2} m v^2$

$= \frac{1}{2} * (4000 + 38000) * 19^2$

$= 7581000$ J

(e) Explain what the effect would be on the velocity of the combined truck and engine if the track was not frictionless.

Because some energy get lost in fricition; the velocity would have been less.

4. The diagram shows a mass attached to a solid flywheel that rotates at 100 RPM.

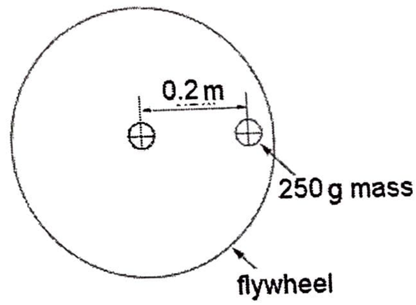


Diagram not to scale

The centre of the mass is 0.2m from the centre of the flywheel.

(a) Calculate the angular frequency of the flywheel to 3 decimal places.

$\omega = 2\pi f = \frac{2 * 3.14 * 100}{60} = 10 \text{ rad/s}$.

(b) Calculate the rotational inertia of the mass attached to the flywheel.

$I = mr^2$

$= 0.25 * 0.2^2 = 0.01 \text{ kg.m}^2$

(c) Calculate the rotational kinetic energy of the mass.

$KE = \frac{1}{2} \cdot I \cdot \omega^2 = \frac{1}{2} * 0.01 * 10^2 = 0.5 J$

(d) Explain the effect of increasing the distance between the centre of the flywheel and the centre of the mass.

ω will not change, decreasing the centripitial accelevation and

KE of the mass will increasing.