GIVE FEEDBACK

CONTINUE >

This section brings together the concepts of torque, rotational speed, power, torsional stress and strain as applied to mechanical drives.

It includes analysis of the transmission of power by a single shaft with multiple power-output points.

Examples of shafts include crankshafts and camshafts.

What is a shaft?

A **shaft** can be described as a rotating machine component subjected to torque and used for the purpose of transmitting mechanical power.

GIVE FEEDBACK

OK

Type your answer in the box.

A [ ] can be described as a rotating machine component subjected to torque and used for the purpose of transmitting mechanical power.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Which of the following is the correct definition of a shaft?

Click the correct answer.

A rotating machine component subjected to torque and used for the purpose of transmitting mechanical power

An oscillating machine component subjected to torque and used for the purpose of transmitting mechanical power

An oscillating machine component subjected to force and used for the purpose of transmitting mechanical power

A rotating machine component subjected to torque and used for the purpose of transmitting electrical power

A stationary machine component subjected to torque and used for the purpose of transmitting mechanical power

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

What is the correct term used to describe a rotating machine component subjected to torque and used for the purpose of transmitting mechanical power?

Click the correct answer.

- A shaft
- A turnbuckle
- A rotor
- An engine
- A lever

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Important relations used in the analysis of power-transmitting shafts

There are three important relations that we should recognise when analysing the transmission of power by shafts:

1. The relation between the applied torque, the speed at which a shaft is rotating and the power transmitted along the axis of the shaft from the power-input point (pulley, gear or sprocket) to the power-output point (another pulley, gear or sprocket)

2. The formula for torsional shear stress which is due to an applied torque

3. The relation between torque, the angle of twist and the modulus of rigidity of the material from which a shaft is made

GIVE FEEDBACK

OK

Which of the following are the correct relations that should be recognised when analysing the power transmission by shafts?

Check all that apply.

- [ ] The relation between the applied torque, the speed at which a shaft is rotating and the power transmitted along the axis of the shaft
- [ ] The formula for torsional shear stress which is due to an applied torque
- [ ] The relation between the applied torque, the torsional shear stress and the power transmitted along the axis of the shaft
- [ ] The relation between torque, the angle of twist and the modulus of rigidity of the material
- [ ] The formula for torsional shear stress which is due to the modulus of rigidity of the material

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Type your answer in the box.

When analysing the power transmitted by shafts, there are three important relations that should be recognised:

1. The relation between the applied _____, the speed at which a shaft is rotating and the power transmitted along the axis of the shaft
2. The formula for torsional shear _____ which is due to an applied torque
3. The relation between torque, the angle of _____ and the modulus of rigidity of the material from which a shaft is made

---

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Recall that this relation is:

$$P = T\,\omega$$

Since rotational speed of mechanical components is usually measured and described in revolutions per minute, it is convenient to incorporate the necessary conversion factors into this formula. Hence power can also be found from:

$$P = \frac{2\pi NT}{60}$$

where N is the rotational speed in revolutions per minute.

Applied torque, shaft speed and power transmitted	Torsional shear stress due to applied torque	Torque, angle of twist and the modulus of rigidity

Formulas used in the analysis of power-transmitting shafts

The second important relation is the formula for torsional shear stress which is due to an applied torque:

$$\sigma_{ts} = \frac{T\,r}{J}$$

where r is the radius of the shaft and J is its polar moment of inertia.

For a solid shaft:

$$r = \frac{D}{2} \qquad \text{and} J = \frac{\pi D^4}{32}$$

For a hollow shaft with outside diameter D_o and inside diameter D_i:

$$r = \frac{D}{2} \qquad \text{and} J = \frac{\pi (D_o^4 - D_i^4)}{32}$$

Applied torque, shaft speed and power transmitted	Torsional shear stress due to applied torque	Torque, angle of twist and the modulus of rigidity

GIVE FEEDBACK

OK

Formulas used in the analysis of power-transmitting shafts

The third useful relation is that between torque, the angle of twist and the modulus of rigidity of the material from which a shaft is made:

$$\theta = \frac{TL}{JG}$$

where:
θ is the angle of twist
T is the torque
L is the shaft length
J is the polar moment of inertia
G is the material modulus of rigidity

Applied torque, shaft speed and power transmitted	Torsional shear stress due to applied torque	Torque, angle of twist and the modulus of rigidity

Match each of the symbols from the equation $P = \frac{2\pi NT}{60}$ with the correct description.

Drag statements on the right to match the left.

P	The power transmitted by the shaft
N	The rotational speed in revolutions per minute
T	The torque

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Match each of the symbols from the equation $\sigma_{ts} = \frac{Tr}{J}$ with the correct description.

Drag statements on the right to match the left.

σ_{ts}	The torsional shear stress
T	The torque
r	The radius of the shaft
J	The polar moment of inertia of the shaft

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Match each of the symbols from the equation $\theta = \frac{TL}{JG}$ with the correct description.

Drag statements on the right to match the left.

θ	The angle of twist
T	The torque
J	The polar moment of inertia of the shaft
L	The shaft length
G	The material modulus of rigidity

Do you know the answer?

Determine the power transmitted by the shaft

A 35 mm diameter solid shaft rotates at 1440 rpm and transmits 547.1 Nm of torque.

Determine the power transmitted by the shaft.

Example	Power transmitted

GIVE FEEDBACK

OK

Determine the power transmitted by the shaft

Power transmitted:

$$P = \frac{2\pi NT}{60}$$
$$= \frac{(2\pi)(1{,}440)(547.1)}{60}$$
$$= 82{,}500 \text{ W}$$
$$= 82.5 \text{ kW}$$

Example | Power transmitted

GIVE FEEDBACK

OK

A solid shaft rotates at 2000 rpm and transmits 265 Nm of torque.

Determine the power transmitted by the shaft.

(Answer in kW correct to one decimal place.)

Clear

Clear line

Undo

Click and type your answer here

CHALLENGE

SUBMIT

SHOW ANSWER

INSTRUCTIONS

- No intermediate steps are required
- If you choose to show steps, write one on each line.
- Write your final answer on the last line.
- The computer will check all your work in detail when you click "Submit".

Hint

Each hint will reduce the credit received for this question

A shaft rotates at 6000 rpm and transmits 400 Nm of torque. Determine the power transmitted by the shaft.

(Answer in kW correct to one decimal place.)

Clear

Clear line

?

Undo

Click and type your answer here

CHALLENGE

SUBMIT

SHOW ANSWER

INSTRUCTIONS

- No intermediate steps are required
- If you choose to show steps, write one on each line.
- Write your final answer on the last line.
- The computer will check all your work in detail when you click "Submit".

Hint

Each hint will reduce the credit received for this question

A solid shaft rotates at 1200 rpm and transmits 125 Nm of torque.

Determine the power transmitted by the shaft.

(Answer to the nearest watt.)

Clear

Clear line

?

Undo

Click and type your answer here

CHALLENGE

SUBMIT

SHOW ANSWER

INSTRUCTIONS

- No intermediate steps are required
- If you choose to show steps, write one on each line.
- Write your final answer on the last line.
- The computer will check all your work in detail when you click "Submit".

Hint

Each hint will reduce the credit received for this question

Determine the torque transmitted by the shaft

A 35 mm diameter solid shaft rotates at 1440 rpm and transmits 82.5 kW of power.

Determine the torque transmitted by the shaft.

Example	Torque transmitted

GIVE FEEDBACK

OK

Determine the torque transmitted by the shaft

From $P = \dfrac{2\pi NT}{60}$ and using $82.5\,\text{kW} = 82{,}500\,\text{W}$:

$$T = \frac{60P}{2\pi N}$$
$$= \frac{(60)(82{,}500)}{(2\pi)(1{,}440)}$$
$$= 547.1\,\text{N m}$$

Example | Torque transmitted

GIVE FEEDBACK

OK

A shaft rotates at 900 rpm and transmits 1.5 W of power. Determine the torque transmitted by the shaft.

(Answer in Nm correct to one decimal place.)

Clear

Clear line

Undo

Click and type your answer here

CHALLENGE

SUBMIT

SHOW ANSWER

INSTRUCTIONS

- No intermediate steps are required
- If you choose to show steps, write one on each line.
- Write your final answer on the last line.
- The computer will check all your work in detail when you click "Submit".

Hint

Each hint will reduce the credit received for this question

A shaft rotates at 6500 rpm and transmits 221 kW of power. Determine the torque transmitted by the shaft.

(Answer in Nm correct to one decimal place.)

Clear

Clear line

Undo

Click and type your answer here

CHALLENGE

SUBMIT

SHOW ANSWER

INSTRUCTIONS

- No intermediate steps are required
- If you choose to show steps, write one on each line.
- Write your final answer on the last line.
- The computer will check all your work in detail when you click "Submit".

Hint

Each hint will reduce the credit received for this question

A shaft rotates at 4000 rpm and transmits 92 kW of power. Determine the torque transmitted by the shaft.

(Answer in Nm correct to one decimal place.)

Clear

Clear line

Undo

Click and type your answer here

CHALLENGE

SUBMIT

SHOW ANSWER

INSTRUCTIONS

- No intermediate steps are required
- If you choose to show steps, write one on each line.
- Write your final answer on the last line.
- The computer will check all your work in detail when you click "Submit".

Hint

Each hint will reduce the credit received for this question

Determine the stress in the shaft

A 35 mm diameter solid shaft rotates at 1440 rpm and transmits 82.5 kW of power.

Determine the stress in the shaft.

Example	Torque transmitted	Shaft polar moment of inertia	Stress in shaft

GIVE FEEDBACK

OK

Determine the stress in the shaft

From: $P = \dfrac{2\pi NT}{60}$ and using $82.5\,\text{kW} = 82{,}500\,\text{W}$:

$$
\begin{aligned}
T &= \frac{60P}{2\pi N} \\
&= \frac{(60)(82{,}500)}{(2\pi)(1{,}440)} \\
&= 547.1\,\text{N m} \\
&= 547{,}100\,\text{N mm}
\end{aligned}
$$

Example	Torque transmitted	Shaft polar moment of inertia	Stress in shaft

GIVE FEEDBACK

OK

Determine the stress in the shaft

For a 35 mm diameter shaft, $r = 17.5\,\text{mm}$ and:

$$J = \frac{\pi \times 35^4}{32}$$
$$= 147.3 \times 10^3\,\text{mm}^4$$

Example	Torque transmitted	Shaft polar moment of inertia	Stress in shaft

GIVE FEEDBACK

OK

Determine the stress in the shaft

Stress in shaft:

$$\sigma_{ts} = \frac{T\,r}{J}$$

$$= \frac{547{,}100\ \text{N.mm} \times 17.5\ \text{mm}}{147.3 \times 10^3\ \text{mm}^4}$$

$$= 65\ \text{MPa}$$

Example	Torque transmitted	Shaft polar moment of inertia	Stress in shaft

GIVE FEEDBACK

OK

A 64 mm diameter solid shaft rotates at 3000 rpm and transmits 482 Nm of torque.

Determine the stress in the shaft.

SMALL MEDIUM LARGE

Type your answer in the box.

The polar moment of inertia of the shaft is _____ mm^4 (correct to the nearest whole number).

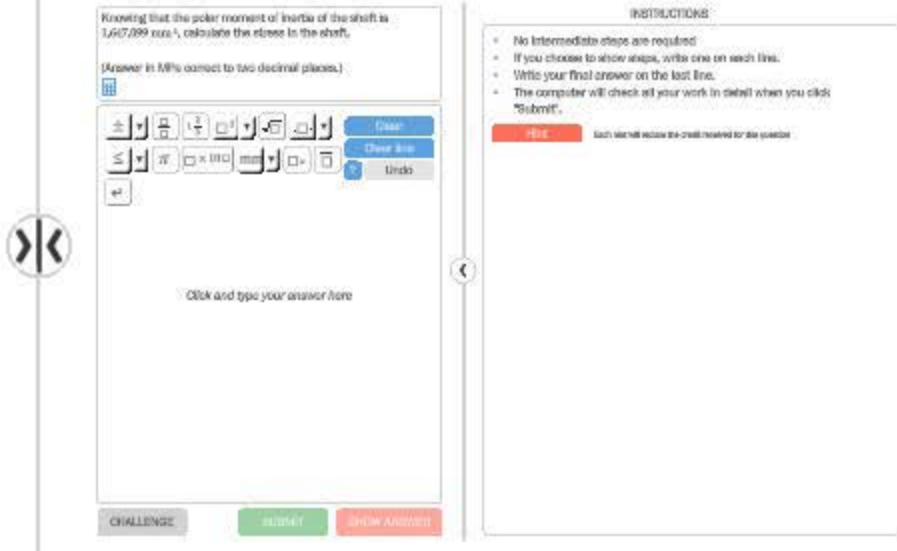
Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A 64 mm diameter solid shaft rotates at 3000 rpm and transmits 482 Nm of torque.

Determine the stress in the shaft.

SMALL MEDIUM LARGE



Type your answer in the box.

The polar moment of inertia of the shaft is _____ mm^4 (correct to the nearest whole number).

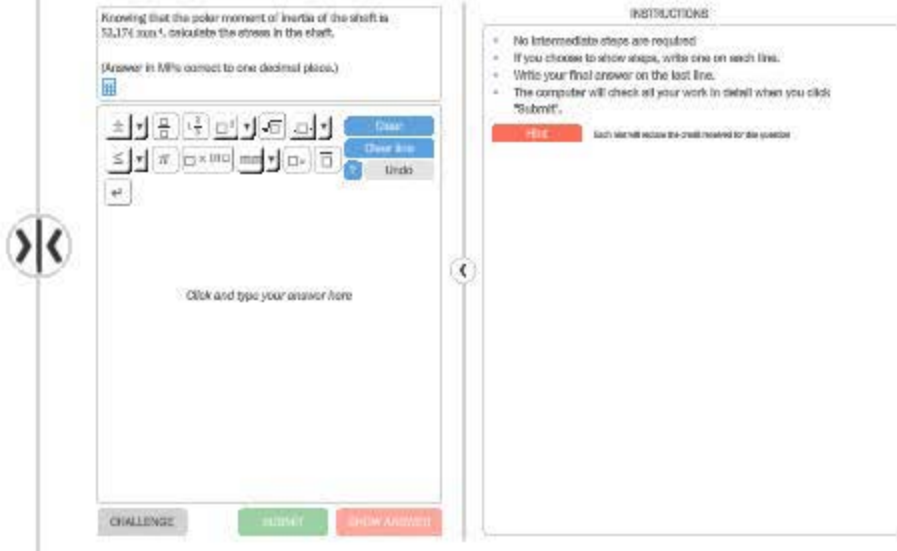
Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A 27 mm diameter solid shaft rotates at 1200 rpm and transmits 125 Nm of torque.

Determine the stress in the shaft.

SMALL MEDIUM LARGE



Knowing that the polar moment of inertia of the shaft is $1{,}647{,}099\ \text{mm}^4$, calculate the stress in the shaft.

(Answer in MPa correct to two decimal places.)

Clear

Clear line

Undo

Click and type your answer here

CHALLENGE

SUBMIT

SHOW ANSWER

INSTRUCTIONS

- No intermediate steps are required
- If you choose to show steps, write one on each line.
- Write your final answer on the last line.
- The computer will check all your work in detail when you click "Submit".

Hint

Each hint will reduce the credit received for this question

Knowing that the polar moment of inertia of the shaft is $52{,}174\ \text{mm}^4$, calculate the stress in the shaft.

(Answer in MPa correct to one decimal place.)

Clear

Clear line

Undo

Click and type your answer here

CHALLENGE

SUBMIT

SHOW ANSWER

INSTRUCTIONS

- No intermediate steps are required
- If you choose to show steps, write one on each line.
- Write your final answer on the last line.
- The computer will check all your work in detail when you click "Submit".

Hint

Each hint will reduce the credit received for this question

Calculate the angle of twist of the shaft

A 35 mm diameter solid shaft rotates at 1440 rpm and transmits 82.5 kW of power.

If the material of the shaft is steel, with modulus of rigidity $G = 80{,}000\ \mathrm{MPa}$, and the shaft is 600 mm long, what is the angle of twist?

Example	Torque transmitted	Shaft polar moment of inertia	Angle of twist

GIVE FEEDBACK

OK

Calculate the angle of twist of the shaft

From: $P = \dfrac{2\pi NT}{60}$ and using $82.5\,\text{kW} = 82{,}500\,\text{W}$:

$$
\begin{aligned}
T &= \frac{60P}{2\pi N} \\
&= \frac{(60)(82{,}500)}{(2\pi)(1{,}440)} \\
&= 547.1\,\text{N m} \\
&= 547{,}100\,\text{N mm}
\end{aligned}
$$

Example	Torque transmitted	Shaft polar moment of inertia	Angle of twist

GIVE FEEDBACK

OK

Calculate the angle of twist of the shaft

For a 35 mm diameter shaft, $r = 17.5\,\text{mm}$, and:

$$J = \frac{\pi \times 35^4}{32}$$
$$= 147.3 \times 10^3\,\text{mm}^4$$

Example	Torque transmitted	Shaft polar moment of inertia	Angle of twist

GIVE FEEDBACK

OK

Calculate the angle of twist of the shaft

The angle of twist is found by substitution into the appropriate formula:

$$\theta = \frac{TL}{JG}$$
$$= \frac{547{,}100\ \text{N.mm} \times 600\ \text{mm}}{147.3 \times 10^3\ \text{mm}^4 \times 80{,}000\ \text{MPa}}$$
$$= 0.02786\ \text{rad}$$

Conversion to degrees yields $\theta = 1.6°$.

Example	Torque transmitted	Shaft polar moment of inertia	Angle of twist

GIVE FEEDBACK

OK

Type your answer in the box.

A shaft with a polar moment of inertia of $1.6 \times 10^6\ \text{mm}^4$ transmits $482\ \text{N m}$ of torque. The material of the shaft is steel, with modulus of rigidity $G = 80{,}000\ \text{MPa}$, and the shaft is $650\ \text{mm}$ long.

The angle of twist is [ ] radians (correct to four decimal places), which is equivalent to [ ] degrees (correct to two decimal places).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Type your answer in the box.

A shaft with a polar moment of inertia of $73{,}000\ \text{mm}^4$ transmits $326\ \text{N m}$ of torque. The material of the shaft is steel, with modulus of rigidity $G = 80{,}000\ \text{MPa}$, and the shaft is $1{,}150\ \text{mm}$ long.

The angle of twist is [ ] radians (correct to four decimal places), which is equivalent to [ ] degrees (correct to two decimal places).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Type your answer in the box.

A shaft with a polar moment of inertia of $150{,}000\ \text{mm}^4$ transmits $125\ \text{N m}$ of torque. The material of the shaft is steel, with modulus of rigidity $G = 80{,}000\ \text{MPa}$, and the shaft is $750\ \text{mm}$ long.

The angle of twist is _____ radians (correct to four decimal places), which is equivalent to _____ degrees (correct to two decimal places).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Shaft with multiple power-output points

It is not uncommon for a single shaft to have more than one power-output point through several gears, pulleys or sprockets spaced along the length of the shaft.

This means that different portions of the shaft, while all rotating at the same speed as a whole, transmit different amounts of mechanical power and experience different magnitudes of torque.

GIVE FEEDBACK

OK

Type your answer in the box.

It is not uncommon for a single shaft to have more than one power-output point through several _____, _____ or _____ spaced along the length of the shaft.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Type your answer in the box.

The use of multiple power-output points on one shaft means that different portions of the shaft, while all rotating at the same speed as a whole, transmit different amounts of mechanical _____ and experience different magnitudes of _____.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Which of the following statements is true for a single shaft with multiple output points?

Click the correct answer.

Different portions of the shaft transmit different amounts of mechanical power and experience different magnitudes of torque

All portions of the shaft transmit equal amounts of mechanical power and experience equal magnitudes of torque

Different portions of the shaft transmit different amounts of mechanical power but they all experience equal magnitudes of torque

All portions of the shaft transmit equal amounts of mechanical power but they experience different magnitudes of torque

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

The analogy between transmission of power by shafts and water-flowing pipes

It is best to approach the problem of multiple outputs from a single shaft from the point of view of energy conservation.

We can use the analogy between the flow of power through different portions of the shaft and the flow of water inside pipes with several take-off taps. The principle is the same for both: what flows in must flow out.

Once the flow of power has been analysed, torque which is related to corresponding amounts of power in different portions of the shaft can easily be determined.

GIVE FEEDBACK

OK

When approaching the problem of multiple outputs from a single shaft, which principle should be utilised?

Click the correct answer.

- Conservation of energy
- Conservation of matter
- Conservation of momentum
- Environmental conservation

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Type your answer in the box.

It is best to approach the problem of multiple outputs from a single shaft from the point of view of energy conservation.

The principle is that what flows _____ must flow _____.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

What is the basic principle of the analogy between the flow of power through different portions of a shaft and the flow of water inside pipes with several take-off taps?

Click the correct answer.

- What flows in must flow out
- Water flows downhill
- What flows in must be greater than what flows out
- What flows in must be less than what flows out
- Pressure determines output

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Identify power transmitted through different parts of a shaft

A line shaft $ABCD$ rotates at 960 rpm and has 120 kW of power input through Pulley B, with three power-output pulleys as follows:

Pulley A: 45 kW
Pulley C: 25 kW
Pulley D: 50 kW

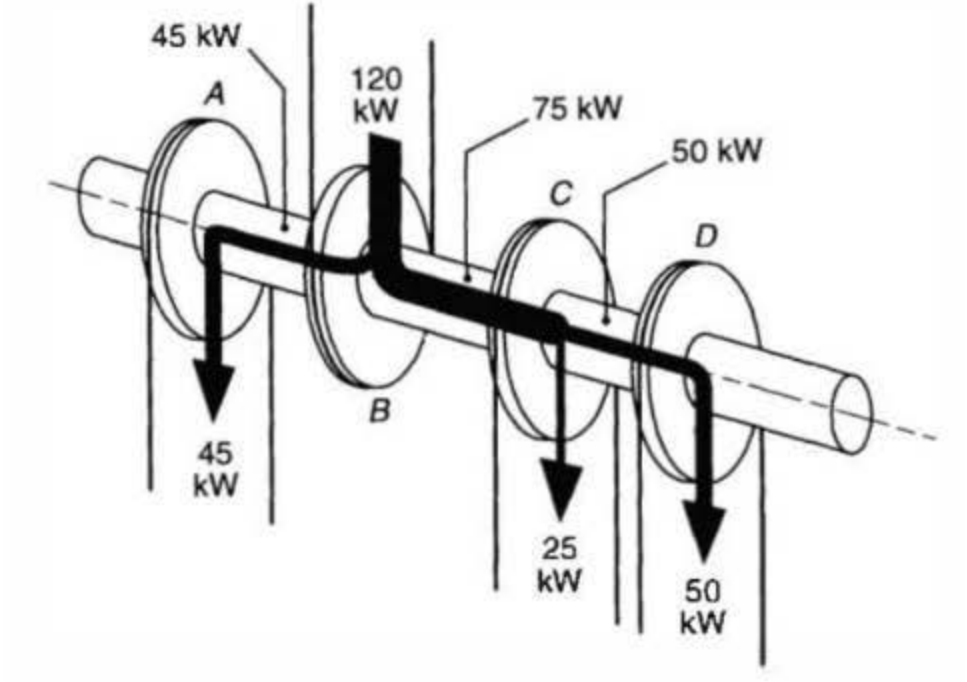
Determine the power in each portion of the shaft.

Example	Figure	Solution

GIVE FEEDBACK

OK

Identify power transmitted through different parts of a shaft



Example | Figure | Solution

GIVE FEEDBACK

OK

Note that the amount of power carried by each portion of the shaft is cumulative if viewed in the reverse direction, i.e. from the extreme output ends towards the input point.

Therefore power carried by portion BC is the amount equal to the sum of the power outputs at C and D, while portion CD only needs to carry the amount of power leaving through Pulley D.

Therefore:

$$P_{AB} = 45\ \text{kW}$$
$$P_{BC} = 75\ \text{kW}$$
$$P_{CD} = 50\ \text{kW}$$

Example | Figure | Solution

Type your answer in the box.

A shaft has four pulleys attached to it. From left to right the pulleys are A, B, C and D:

- Pulley A outputs 10 kW from the shaft
- Pulley B outputs 30 kW from the shaft
- Pulley C outputs 60 kW from the shaft

Assuming 100% efficiency, the input from Pulley D is _____ kW.

The power transmitted by the shaft between Pulley A and Pulley B is _____ kW.

The power transmitted by the shaft between Pulley B and Pulley C is _____ kW.

The power transmitted by the shaft between Pulley C and Pulley D is _____ kW.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Type your answer in the box.

A shaft has four pulleys attached to it. From left to right the pulleys are A, B, C and D:

- Pulley A inputs 65 kW to the shaft
- Pulley B outputs 30 kW from the shaft
- Pulley C outputs 20 kW from the shaft

Assuming 100% efficiency, the output from Pulley D is _____ kW.

The power transmitted by the shaft between Pulley A and Pulley B is _____ kW.

The power transmitted by the shaft between Pulley B and Pulley C is _____ kW.

The power transmitted by the shaft between Pulley C and Pulley D is _____ kW.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Type your answer in the box.

A shaft has four gears attached to it. From left to right the gears are A, B, C and D:

- Gear A outputs 150 W from the shaft
- Gear B outputs 250 W from the shaft
- Gear C inputs 700 W to the shaft

Assuming 100% efficiency, the output from Gear D is _____ W.

The power transmitted by the shaft between Gear A and Gear B is _____ W.

The power transmitted by the shaft between Gear B and Gear C is _____ W.

The power transmitted by the shaft between Gear C and Gear D is _____ W.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Calculate the torque that can be transmitted by a shaft within specificed parameters of size and allowable stress

A line shaft $ABCD$ rotates at 960 rpm and has 120 kW of power input through Pulley B, with three power-output pulleys as follows:

Pulley A: 45 kW
Pulley C: 25 kW
Pulley D: 50 kW

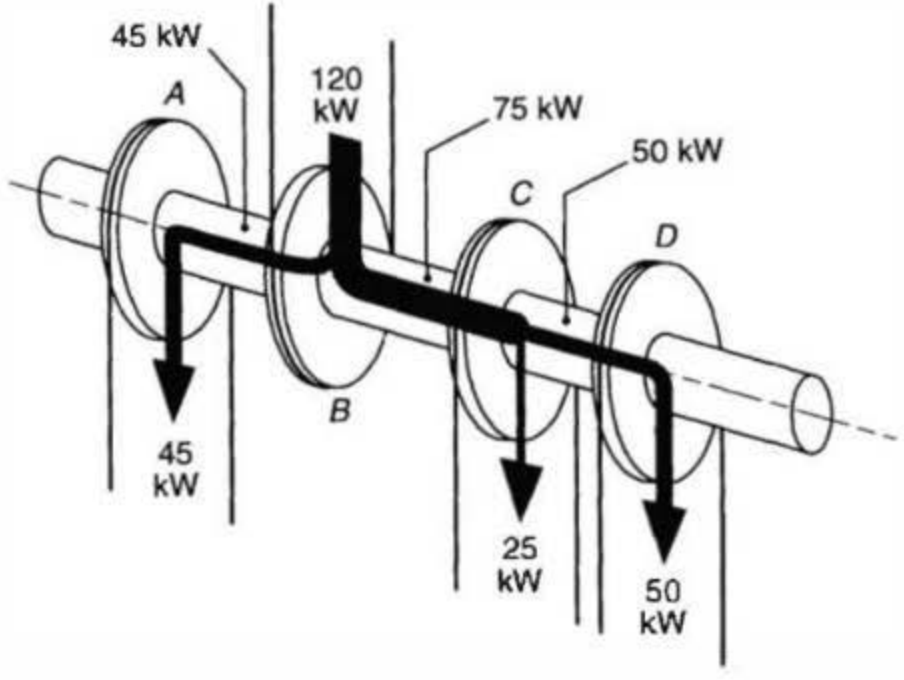
Determine the torque in each portion of the shaft.

Example	Figure	Distribution of power	Distribution of torque

GIVE FEEDBACK

OK

Calculate the torque that can be transmitted by a shaft within specificed parameters of size and allowable stress



Example	Figure	Distribution of power	Distribution of torque

GIVE FEEDBACK

OK

Note that the amount of power carried by each portion of the shaft is cumulative if viewed in the reverse direction, i.e. from the extreme output ends towards the input point.

Therefore power carried by portion BC is the amount equal to the sum of the power outputs at C and D, while portion CD only needs to carry the amount of power leaving through pulley D.

Therefore:

$$P_{AB} = 45\ \text{kW}$$
$$P_{BC} = 75\ \text{kW}$$
$$P_{CD} = 50\ \text{kW}$$

Example	Figure	Distribution of power	Distribution of torque

The corresponding torque values can now be calculated using:

$$P = \frac{2\pi NT}{60}$$

Transposition gives:

$$T = \frac{60P}{2\pi N}$$

Hence:

$$T_{AB} = \frac{60 \times 45{,}000}{2\pi \times 960} = 448 \text{ N m}$$

$$T_{BC} = \frac{60 \times 75{,}000}{2\pi \times 960} = 746 \text{ N m}$$

$$T_{CD} = \frac{60 \times 50{,}000}{2\pi \times 960} = 497 \text{ N m}$$

Example	Figure	Distribution of power	Distribution of torque

Type your answer in the box.

A shaft rotating at 1500 rpm has four pulleys attached to it. From left to right the pulleys are A, B, C and D:

- Pulley A inputs 65 kW to the shaft
- Pulley B outputs 30 kW from the shaft
- Pulley C outputs 20 kW from the shaft
- Pulley D outputs 15 kW from the shaft

The torque transmitted by the shaft between Pulley A and Pulley B is _____ Nm (correct to one decimal place).

The torque transmitted by the shaft between Pulley B and Pulley C is _____ Nm (correct to one decimal place).

The torque transmitted by the shaft between Pulley C and Pulley D is _____ Nm (correct to one decimal place).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Type your answer in the box.

A shaft rotating at 1915 rpm has four pulleys attached to it. From left to right the pulleys are A, B, C and D:

- Pulley A outputs 10 kW from the shaft
- Pulley B outputs 30 kW from the shaft
- Pulley C outputs 60 kW from the shaft
- Pulley D inputs 100 kW to the shaft

The torque transmitted by the shaft between Pulley A and Pulley B is _____ Nm (correct to one decimal place).

The torque transmitted by the shaft between Pulley B and Pulley C is _____ Nm (correct to one decimal place).

The torque transmitted by the shaft between Pulley C and Pulley D is _____ Nm (correct to one decimal place).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Type your answer in the box.

A shaft rotating at 852 rpm has four gears attached to it. From left to right the gears are A, B, C and D:

- Gear A outputs 150 W from the shaft
- Gear B outputs 250 W from the shaft
- Gear C inputs 700 W to the shaft
- Gear D outputs 300 W from the shaft

The torque transmitted by the shaft between Gear A and Gear B is _____ Nm (correct to two decimal places).

The torque transmitted by the shaft between Gear B and Gear C is _____ Nm (correct to two decimal places).

The torque transmitted by the shaft between Gear C and Gear D is _____ Nm (correct to two decimal places).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

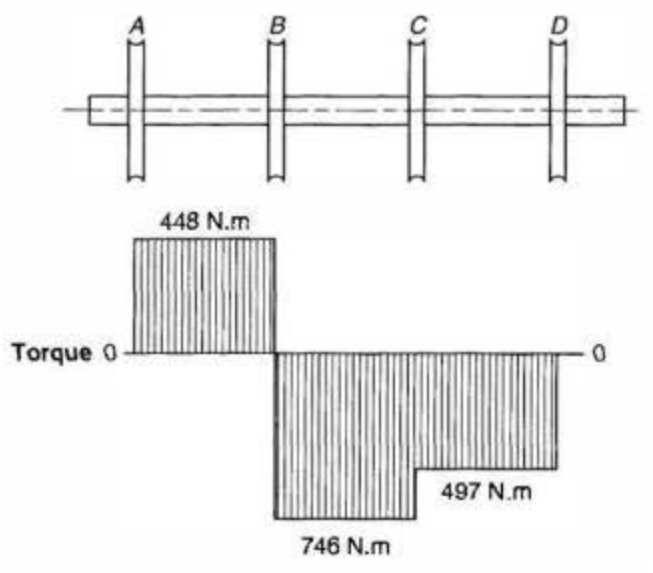
The torque values in a multiple output shaft can be represented in the form of a **torque distribution diagram**, similar to shear force diagrams for beams.

The figure below shows the distribution of torque in a shaft with the following torque values:

$$T_{AB} = \frac{60 \times 45{,}000}{2\pi \times 960} = 448 \text{ N m}$$

$$T_{BC} = \frac{60 \times 75{,}000}{2\pi \times 960} = 746 \text{ N m}$$

$$T_{CD} = \frac{60 \times 50{,}000}{2\pi \times 960} = 497 \text{ N m}$$



Torque distribution diagram

What information is provided by a torque distribution diagram?

Click the correct answer.

- The torque values for a shaft with multiple outputs
- The outputs for a shaft with multiple torques
- The outputs for a shaft with a single torque input
- The torque values for a given force distribution

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Type your answer in the box.

The torque values in a multiple output shaft can be represented in the form of a _____ diagram, similar to shear force diagrams for beams.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

What is the correct name given to the graphical representation of the torque values for a shaft with multiple outputs?

Click the correct answer.

- Torque distribution diagram
- Shear force diagram
- Bending moment diagram
- Torque output distribution
- Shear force distribution

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Calculating the required diameter of a solid shaft when torque and allowable stress are given

A useful design-oriented formula for solid shafts can be obtained by combining the equation for torsional shear stress with the equation for the polar moment of inertia of a solid shaft.

$$D = \sqrt[3]{\frac{16\,T}{\pi \sigma_{ts}}}$$

where:

D is the required diameter

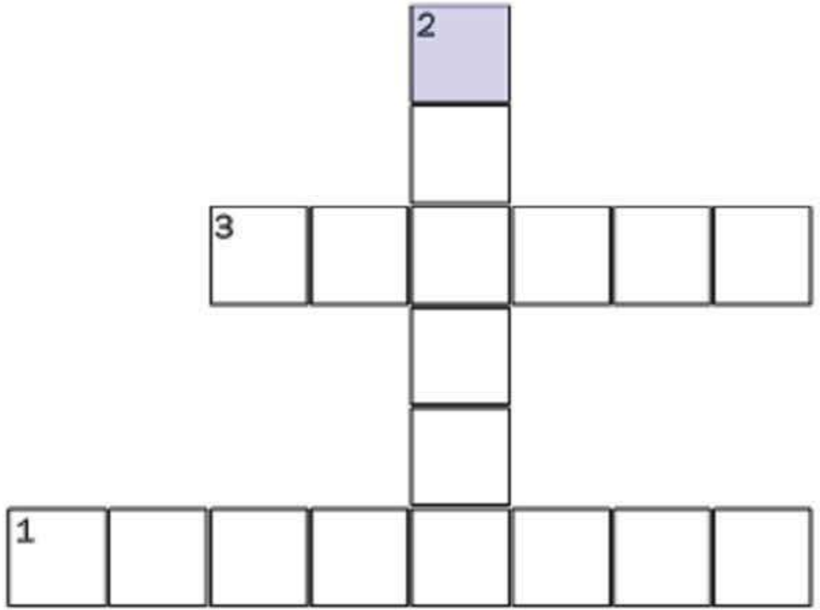
T is the torque

σ_{ts} is the torsional shear stress

GIVE FEEDBACK

OK

Calculating required diameter



Complete the crossword for the equation $D = \sqrt[3]{\frac{16T}{\pi\sigma_{ts}}}$.

1) D refers to the _____.

2) T refers to the _____.

3) σ_{ts} refers to the _____.

Done Hint Challenge

Match each of the symbols from the equation $D = \sqrt[3]{\frac{16\,T}{\pi \sigma_{t\,s}}}$ with the correct description.

Drag statements on the right to match the left.

D	The required shaft diameter
T	The torque in the shaft
$\sigma_{t\,s}$	The torsional shear stress in the shaft

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Which of the following is the correct equation for calculation of the required diameter of a solid shaft given the torque?

Click the correct answer.

$$D = \sqrt[3]{\frac{16\,T}{\pi \sigma_{t\,s}}}$$

$$D = \sqrt{\frac{16\,T}{\pi \sigma_{t\,s}}}$$

$$D = \sqrt[3]{\frac{\pi \sigma_{t\,s}}{16\,T}}$$

$$D = \sqrt{\frac{\pi \sigma_{t\,s}}{16\,T}}$$

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Calculate the shaft diameter required to transmit specified torque and power without exceeding allowable stress or angle of twist

It has been decided to make a stepped shaft to suit the conditions specified in the figure and listed below:

$$T_{AB} = \frac{60 \times 45\,0}{2\pi \times 960} = 448\ \text{N m}$$

$$T_{BC} = \frac{60 \times 75\,0}{2\pi \times 960} = 746\ \text{N m}$$

$$T_{CD} = \frac{60 \times 50\,0}{2\pi \times 960} = 497\ \text{N m}$$

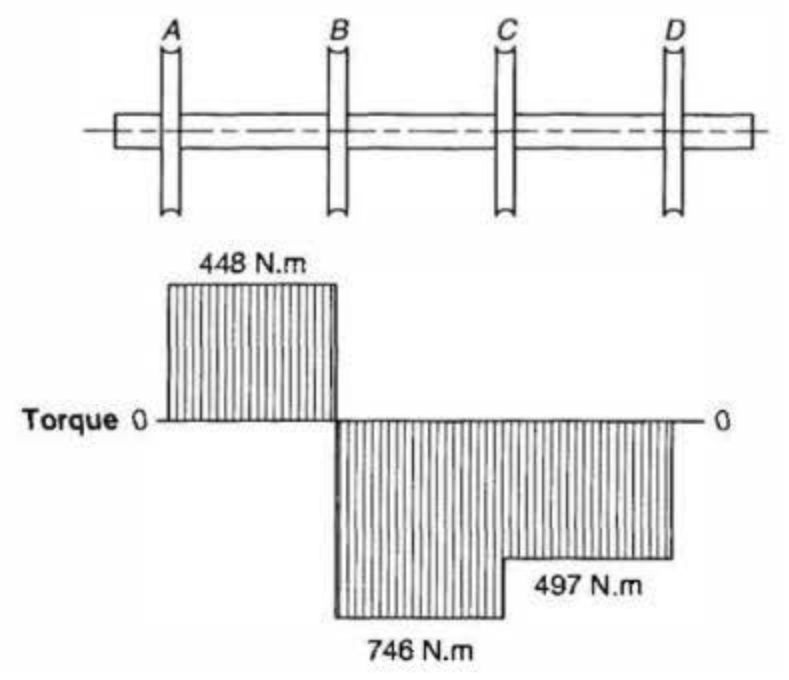
If the allowable stress is 40 MPa, calculate the required diameters.

Example	Figure	Derivation of equation	Solution

GIVE FEEDBACK

OK

Calculate the shaft diameter required to transmit specified torque and power without exceeding allowable stress or angle of twist



Example	Figure	Derivation of equation	Solution

GIVE FEEDBACK

OK

Calculate the shaft diameter required to transmit specified torque and power without exceeding allowable stress or angle of twist

Start with the equation:

$$\sigma_{ts} = \frac{T\,r}{J}$$

and substitute $r = \frac{D}{2}$ and $J = \frac{\pi D^4}{32}$:

$$\sigma_{ts} = \frac{T\,r}{J}$$

$$= \frac{TD \times 32}{2 \times \pi D^4}$$

$$= \frac{16\,T}{\pi D^3}$$

Now make the unknown diameter the subject of the expression:

$$D = \sqrt[3]{\frac{16\,T}{\pi \sigma_{ts}}}$$

Example	Figure	Derivation of equation	Solution

GIVE FEEDBACK

OK

Substitute numerical values and solve:

$$D_{AB} = \sqrt[3]{\frac{16 \times 448{,}000}{\pi \times 40}}$$
$$= 38.5 \text{ mm}$$

Similarly:

$$D_{BC} = 45.6 \text{ mm and } D_{CD} = 39.8 \text{ mm.}$$

Example | Figure | Derivation of equation | Solution

GIVE FEEDBACK

OK

It has been decided to make a stepped shaft to suit the conditions listed below:

- $T_{AB} = 413{,}800\,\text{N mm}$
- $T_{BC} = 222{,}800\,\text{N mm}$
- $T_{CD} = 95{,}500\,\text{N mm}$

The allowable stress is 50 MPa.

SMALL | MEDIUM | LARGE

Calculate the required diameter for section AB of the shaft.

(Answer in millimetres correct to one decimal place.)

Clear | Clear line | Undo

Click and type your answer here

CHALLENGE | SUBMIT | SHOW ANSWER

INSTRUCTIONS

- No intermediate steps are required
- If you choose to show steps, write one on each line.
- Write your final answer on the last line.
- The computer will check all your work in detail when you click "Submit".

Hint — Each hint will reduce the credit received for this question

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- $T_{CD} = 95{,}500\,\text{N mm}$

The allowable stress is 50 MPa.

SMALL | MEDIUM | LARGE

Calculate the required diameter for section BC of the shaft.

(Answer in millimetres correct to one decimal place.)

Clear | Clear line | Undo

Click and type your answer here

CHALLENGE | SUBMIT | SHOW ANSWER

INSTRUCTIONS

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- $T_{CD} = 95{,}500\,\text{N mm}$

The allowable stress is 50 MPa.

SMALL | MEDIUM | LARGE

Calculate the required diameter for section CD of the shaft.

(Answer in millimetres correct to one decimal place.)

Clear | Clear line | Undo

Click and type your answer here

CHALLENGE | SUBMIT | SHOW ANSWER

INSTRUCTIONS

- No intermediate steps are required
- If you choose to show steps, write one on each line.
- Write your final answer on the last line.
- The computer will check all your work in detail when you click "Submit".

Hint — Each hint will reduce the credit received for this question

It has been decided to make a stepped shaft to suit the conditions listed below:

- $T_{AB} = 49{,}700\,\text{N mm}$
- $T_{BC} = 199{,}500\,\text{N mm}$
- $T_{CD} = 498{,}700\,\text{N mm}$

The allowable stress is 55 MPa.

SMALL MEDIUM LARGE

Calculate the required diameter for section AB of the shaft.

(Answer in millimetres correct to one decimal place.)

Clear
Clear line
Undo

Click and type your answer here

CHALLENGE SUBMIT SHOW ANSWER

INSTRUCTIONS

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- Write your final answer on the last line.
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Hint Each hint will reduce the credit received for this question

It has been decided to make a stepped shaft to suit the conditions listed below:

- $T_{AB} = 49{,}700\,\text{N mm}$
- $T_{BC} = 199{,}500\,\text{N mm}$
- $T_{CD} = 498{,}700\,\text{N mm}$

The allowable stress is 55 MPa.

SMALL | MEDIUM | LARGE

Calculate the required diameter for section BC of the shaft.

(Answer in millimetres correct to one decimal place.)

Clear | Clear line | Undo

Click and type your answer here

CHALLENGE | SUBMIT | SHOW ANSWER

INSTRUCTIONS

- No intermediate steps are required
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- $T_{BC} = 199{,}500\,\text{N mm}$
- $T_{CD} = 498{,}700\,\text{N mm}$

The allowable stress is 55 MPa.

SMALL | MEDIUM | LARGE

Calculate the required diameter for section CD of the shaft.

(Answer in millimetres correct to one decimal place.)

Clear | Clear line | Undo

Click and type your answer here

CHALLENGE | SUBMIT | SHOW ANSWER

INSTRUCTIONS

- No intermediate steps are required
- If you choose to show steps, write one on each line.
- Write your final answer on the last line.
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