MATHEMATICAL SKILLS

GEARS, GEAR TRAINS AND COMPOUND GEARS

ASSOCIATED EXAMINATION QUESTIONS

DESIGN AND TECHNOLOGY

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CALCULATING GEAR RATIO (VELOCITY RATIO)

In examinations, one of the first questions will be - to work out the 'gear ratio' (sometimes called velocity ratio). As a guide - always assume that the larger gear revolves one revolution. The number of rotations of the second gear has then to be worked out.

In the example below, the DRIVER has 60 teeth and because it is the largest we say that it revolves once. The DRIVEN gear has 30 teeth. Simply divide 60 teeth by 30 teeth to work out the number of revolutions of the driven gear.

1A.

GEAR RATIO / VELOCITY RATIO

\[
\frac{\text{Distance moved by Effort}}{\text{Distance moved by Load}} = \frac{60T \text{ (GEAR A)}}{30T \text{ (GEAR B)}}
\]

\[
= \frac{1}{2} = \frac{\text{Input movement}}{\text{Output movement}}
\]

\[
= \text{Driver} : \text{Driven}
\]

1 : 2

2A.

GEAR RATIO / VELOCITY RATIO

\[
\frac{\text{Distance moved by Effort}}{\text{Distance moved by Load}} = \frac{25T \text{ (GEAR A)}}{75T \text{ (GEAR B)}}
\]

\[
= \frac{3}{1} = \frac{\text{Input movement}}{\text{Output movement}}
\]

\[
= \text{Driver} : \text{Driven}
\]

3 : 1

3A.

GEAR RATIO / VELOCITY RATIO

\[
\frac{\text{Distance moved by Effort}}{\text{Distance moved by Load}} = \frac{20T \text{ (GEAR A)}}{80T \text{ (GEAR B)}}
\]

\[
= \frac{4}{1} = \frac{\text{Input movement}}{\text{Output movement}}
\]

\[
= \text{Driver} : \text{Driven}
\]

4 : 1
CALCULATING GEAR RATIO (VELOCITY RATIO)

In examinations, one of the first questions will be - to work out the 'gear ratio' (sometimes called velocity ratio). As a guide - always assume that the larger gear revolves one revolution. The number of rotations of the second gear has then to be worked out.

1A.

\[
\begin{array}{c}
\text{Driver (Effort)} \\
60 \text{ TEETH} \\
\text{Driver (Effort)} \\
30 \text{ TEETH}
\end{array}
\]

\begin{align*}
\text{Distance moved by Effort} & = \\
\text{Distance moved by Load} & = \\
\text{Input movement} & = \\
\text{Output movement} & = \\
\text{Driver : Driven} & =
\end{align*}

2A.

\[
\begin{array}{c}
\text{Driver (Effort)} \\
25 \text{ TEETH} \\
\text{Driver (Effort)} \\
75 \text{ TEETH}
\end{array}
\]

\begin{align*}
\text{Distance moved by Effort} & = \\
\text{Distance moved by Load} & = \\
\text{Input movement} & = \\
\text{Output movement} & = \\
\text{Driver : Driven} & =
\end{align*}

3A.

\[
\begin{array}{c}
\text{Driver (Effort)} \\
20 \text{ TEETH} \\
\text{Driver (Effort)} \\
80 \text{ TEETH}
\end{array}
\]

\begin{align*}
\text{Distance moved by Effort} & = \\
\text{Distance moved by Load} & = \\
\text{Input movement} & = \\
\text{Output movement} & = \\
\text{Driver : Driven} & =
\end{align*}
CALCULATING REVOLUTIONS PER MINUTE (RPM)

In the example below, the DRIVER gear is larger than the DRIVEN gear. The general rule is - large to small gear means 'multiply' the velocity ratio by the rpm of the first gear. Divide 60 teeth by 30 teeth to find the velocity ratio. Multiply this number (2) by the rpm (120). This gives an answer of 240 rpm.

\[
\begin{array}{c|c}
\text{GEAR A} & \text{GEAR B} \\
60 \text{ teeth} & 30 \text{ teeth} \\
120 \text{ rpm} & ?
\end{array}
\]

\[
\frac{60}{30} = 2
\]

\[
= 120 \times 2 = 240 \text{ revs/min}
\]

---

\[
\begin{array}{c|c}
\text{GEAR A} & \text{GEAR B} \\
25 \text{ teeth} & 75 \text{ teeth} \\
60 \text{ rpm} & ?
\end{array}
\]

\[
\frac{75}{25} = 3
\]

\[
= \frac{60}{3} = 20 \text{ revs/min}
\]

---

\[
\begin{array}{c|c}
\text{GEAR A} & \text{GEAR B} \\
20 \text{ teeth} & 80 \text{ teeth} \\
100 \text{ rpm} & ?
\end{array}
\]

\[
\frac{80}{20} = 4
\]

\[
= \frac{100}{4} = 25 \text{ revs/min}
\]
CALCULATING REVOLUTIONS PER MINUTE (RPM)

GEAR A    GEAR B
60 teeth   30 teeth
120 rpm

--- =

= = revs/min

GEAR A    GEAR B
25 teeth   75 teeth
60 rpm

--- =

= = revs/min

GEAR A    GEAR B
20 teeth   80 teeth
100 rpm

--- =

= = revs/min
When faced with three gears, the question can be broken down into two parts. First work on Gears A and B. When this has been solved, work on gears B and C.

The diagram above shows a gear train composed of three gears. Gear A revolves at 60 revs/min in a clockwise direction.

What is the output in revolutions per minute at Gear C?
In what direction does Gear C revolve?

First work out the speed at Gear B.

\[
\frac{60 \text{ teeth}}{20 \text{ teeth}} \times \frac{B}{A} = 3
\]

\[
\frac{60 \text{ rpm}}{3} = 20 \text{ revs/min at ‘B’}
\]

(Remember B is larger than A therefore, B outputs less revs/min and is slower)

Next, take B and C. C is smaller, therefore, revs/minute will increase and rotation will be faster.

\[
\frac{60 \text{ teeth}}{10 \text{ teeth}} \times \frac{B}{C} = 6
\]

\[
20 \text{ REVS} \times 6 = 120 \text{ revs/min at ‘C’}
\]

What direction does C revolve?
A is clockwise, B consequently is anti-clockwise and C is therefore clockwise.
GEAR TRAINS - EXAMPLE QUESTIONS

When faced with three gears the question can be broken down into two parts. First work on Gears A and B. When this has been solved work on gears B and C.

The diagram above shows a gear train composed of three gears. Gear A revolves at 60 revs/min in a clockwise direction. What is the output in revolutions per minute at Gear C? In what direction does Gear C revolve?

First work out the speed at Gear B. 

\[
\frac{\text{teeth at A}}{\text{teeth at B}} = \frac{20}{60} = 60 \text{rpm}
\]

(Remember B is larger than A therefore, B outputs less revs/min and is slower)

Next, take B and C. C is smaller, therefore, revs/minute will increase and rotation will be faster.

\[
\frac{\text{teeth at B}}{\text{teeth at C}} = \frac{60}{10} = \text{__REVS X __} = \text{____revs/min at ‘C’}
\]

What direction does C revolve?
A is clockwise, B consequently is anti-clockwise and C is therefore ________________
When faced with three gears the question can be broken down into two parts. First work on Gears A and B. When this has been solved work on gears B and C.

The diagram opposite shows a gear train composed of three gears. Gear A revolves at 90 revs/min in a clockwise direction. What is the output in revolutions per minute at Gear C? In what direction does Gear C revolve?

GEAR TRAINS - EXAMPLE QUESTIONS AND ANSWERS

First work out the speed at Gear B. \[
\frac{90 \text{ teeth}}{30 \text{ teeth}} \times \frac{B}{A} = 3
\]
\[
\frac{90 \text{ rpm}}{3} = 30 \text{ revs/min at ‘B’}
\]
(Remember B is larger than A therefore, B outputs less revs/min and is slower)

Next, take B and C. C is smaller, therefore, revs/minute will increase and rotation will be faster.

\[
\frac{90 \text{ teeth}}{15 \text{ teeth}} \times \frac{B}{C} = 6
\]

30 REVS X 6 = 180 revs/min at ‘C’

What direction does C revolve? A is clockwise, B consequently is anti-clockwise and C is therefore clockwise.
When faced with three gears the question can be broken down into two parts. First work on Gears A and B. When this has been solved work on gears B and C.

The diagram opposite shows a gear train composed of three gears. Gear A revolves at 90 revs/min in a clockwise direction. What is the output in revolutions per minute at Gear C?

In what direction does Gear C revolve?

<table>
<thead>
<tr>
<th>GEAR A</th>
<th>GEAR B</th>
<th>GEAR C</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 teeth</td>
<td>90 teeth</td>
<td>15 teeth</td>
</tr>
<tr>
<td>90 rpm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

First work out the speed at Gear B.

\[
\frac{\text{teeth}}{\text{teeth}} \frac{B}{A} = \frac{90\text{rpm}}{90\text{rpm}} = \_ \_ \text{revs/min at ‘B’}
\]

(Remember B is larger than A therefore, B outputs less revs/min and is slower)

Next, take B and C. C is smaller, therefore, revs/minute will increase and rotation will be faster.

\[
\frac{\text{teeth}}{\text{teeth}} \frac{B}{C} = \_ \_ \text{REVS} \times \_ \_ = \_ \_ \text{revs/min at ‘C’}
\]

What direction does C revolve?
A is clockwise, B consequently is anti-clockwise and C is therefore _____________
Below is a question regarding 'compound gears'. Gears C and B represent a compound gear as they appear 'fixed' together. When drawn with a compass they have the same centre. Two gears 'fixed' together in this way rotate together and at the same RPM. When answering a question like this split it into two parts. Treat gears A and B as one question AND C and D as the second part.

This is an example of a “compound gear train”. Gear A rotates in a clockwise direction at 30 revs/min. What is the output in revs/min at D and what is the direction of rotation?

<table>
<thead>
<tr>
<th>GEAR A</th>
<th>GEAR B</th>
<th>GEAR C</th>
<th>GEAR D</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 teeth</td>
<td>40 teeth</td>
<td>80 teeth</td>
<td>20 teeth</td>
</tr>
</tbody>
</table>

First find revs/min at Gear B.

\[
\frac{120 \text{ teeth}}{40 \text{ teeth}} \times \frac{B}{A} = \frac{3}{1}
\]

30 rpm \( \times 3 = 90 \text{ rpm / min} \)

B is smaller therefore it rotates faster and revs/min increase.

C is fixed to B and therefore, rotates at the same speed.

90 REVS/MIN at C

Next find revs/min at Gear D.

\[
\frac{80 \text{ teeth}}{20 \text{ teeth}} \times \frac{C}{D} = \frac{4}{1}
\]

90 rpm (at C) \( \times 4 = 360 \text{ rpm / min} \)

D is smaller than C, therefore rotates faster (increased revs/min).

A revolves in a clockwise direction, B is therefore anti-clockwise, C is fixed to B and is also anti-clockwise, which means D revolves in a clockwise direction.
This is an example of a “compound gear train”. Gear A rotates in a clockwise direction at 30 revs/min. What is the output in revs/min at D and what is the direction of rotation?

**Table:**

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<td>120 teeth</td>
<td>40 teeth</td>
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</tr>
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</table>

First find revs/min at Gear B.

\[ \frac{\text{teeth}_B}{\text{teeth}_A} = \]

\[ \_ \text{rpm} \times \_ = \_ \text{rpm} / \text{min} \]

B is smaller therefore it rotates faster and revs/min increase.

C is fixed to B and therefore, rotates at the same speed.

\[ \_ \text{REVs/MIN at C} \]

Next find revs/min at Gear D.

\[ \frac{\text{teeth}_C}{\text{teeth}_D} = \]

\[ \_ \text{rpm (at C)} \times \_ = \_ \text{rpm} / \text{min} \]

D is smaller than C, therefore rotates faster (increased revs/min).

A revolves in a clockwise direction, B is therefore anti-clockwise, C is fixed to B and is also anti-clockwise, which means D revolves in a _________ direction.
Try the following question:

What is the revs/min at gear D and what is its direction?