

Design & Technology

Edexcel GCSE

Gears

Materials required for questions

- Pencil
- Rubber
- Calculator

Instructions

- Use black ink or ball-point pen
- Try answer all questions
- Use the space provided to answer questions
- Calculators can be used if necessary
- For the multiple choice questions, circle your answer

Advice

- Marks for each question are in brackets
- Read each question fully
- Try to answer every question
- Don't spend too much time on one question

Good luck!

Q1. In a simple gear train with two gears, the driven gear turns

- A** in the same direction as the driver
- B** in the opposite direction to the driver
- C** at 90° to the driver

Q2. What does an idler gear do?

- A** Makes the driver and driven gears turn in the same direction
- B** Doubles the speed of the driven gear
- C** Converts rotary motion into linear motion

Q3. Which gear system converts rotary motion into linear motion?

- A** Bevel gears
- B** Worm gear
- C** Rack and pinion

Q4. Gear A has 20 teeth and drives gear B, which has 60 teeth. If gear A rotates three times, how many times will gear B rotate?

- A** One rotation
- B** Three rotations
- C** Nine rotations

Q5. Which gear system turns rotary motion through 90°, and is used in a hand whisk?

- A** Rack and pinion
- B** Bevel gears
- C** Idler gear

Q6. Why can a worm gear not be driven backwards?

- A** The worm is made of a softer material
- B** It has no teeth
- C** The worm wheel cannot turn the worm, so it locks

Q7. An electrically powered hand drill is being redesigned. The manufacturer is considering using a bevel gear inside.

Q7a. Explain one reason for using a bevel gear inside the electrically powered hand drill. **(2 marks)**

The drill also has a compound gear train inside. A 40-tooth driver gear meshes with a 20-tooth gear. This 20-tooth gear is fixed on the same shaft as a second 40-tooth gear, which meshes with a 20-tooth driven gear.

Q7b. Calculate the revolutions per minute (RPM) of the driven gear if the driver gear rotates at 400 RPM. **(2 marks)**

Q8. A LEGO merry-go-round uses a gear mechanism. The handle turns the drive gear, which has 32 teeth, and the driven gear has 16 teeth.

Q8a. Calculate the gear ratio. Show all workings. **(2 marks)**

Q8b. If the handle rotates three times, calculate how many full rotations the merry-go-round will make. Show all workings. **(2 marks)**

Q8c. Using an example of a named product, explain the motion of a rack and pinion gear. **(3 marks)**

Name of product:

Q9. A bicycle uses a gear system.

Q9a. Explain one reason why gears are used on bicycles. **(2 marks)**

Q9b. In a simple gear train, state what effect increasing the size of the driver gear will have on the driven gear. **(1 mark)**

Q9c. A different gear train has an idler gear between the driver gear and the driven gear. Describe the main function of an idler gear. **(1 mark)**

Q10. This question is about bicycle gear calculations.

Q10a. A bicycle has a 12-tooth rear gear and a 48-tooth front gear. Calculate the ratio of the gears used on the bicycle. Show all workings. **(2 marks)**

Q10b. On an electric bicycle, the driven gear has 10 teeth and the driver gear has 40 teeth. State how many rotations the driven gear makes if the driver gear rotates once. **(1 mark)**

Answers

Q1. B

Q2. A

Q3. C

Q4. A

Q5. B

Q6. C

Q7a.

Any one reason for using a bevel gear (1 mark) and a linked reason for the use (1 mark):

- To convert rotary motion through 90° (1), so it will take up less space inside the drill (1)
- To increase/decrease rotary speed (1), which means the chuck can be made to turn faster/slower than the motor speed (1)
- To increase the torque (1), which means it will be able to drill harder/denser materials (1)

Q7b.

A calculation that includes:

- Correct calculation of the compound gear ratio: $(40 \div 20) \times (40 \div 20) = 4$ (1)
- Correct calculation of driven RPM: $4 \times 400 = 1600$ RPM (1)
- Alternative method: $40 \div 20 = 2$, $2 \times 400 = 800$ (1); $40 \div 20 = 2$, $2 \times 800 = 1600$ (1)
- Special case: if only one step is calculated (answer 800) with working, award 1 mark; 800 with no working scores 0

Q8a.

Either ratio calculation is accepted (2 marks): teeth on driven $\div$ teeth on drive = $16/32$ (1) = 1:2 (1); or teeth on drive $\div$ teeth on driven = $32/16$ (1) = 2:1 (1).

Q8b.

Three turns of the 32-tooth gear produce six turns of the merry-go-round: $32 \times 3 = 96$ (1); $96 \div 16 = 6$ rotations (1). Credit any appropriate calculation.

Q8c.

Up to 2 marks for showing understanding of rack and pinion motion and 1 mark for an appropriate product. For example: a rack and pinion is a gear system used to change between rotary and linear motion (1). A stairlift is a product example (1). The rack is fixed to the stairs and the pinion (driven by a motor) climbs up the rack, moving the stairlift (1). Other products: car jack, sliding gate, pillar drill, steering rack on a car or go-kart.

Q9a.

Up to two marks for one reason explained (1 mark for a reason, 1 mark for relating it to the effect on cycling), e.g.:

- Moving the chain from the smallest to the largest gear eases pedalling effort (1), making uphill easier (1)
- A broader range of gears for a given situation (1), e.g. a low gear to accelerate from a standstill or climb a hill (1)
- A high gear helps you to achieve high speeds (1)
- To maintain a suitable pedal speed (1) in varying conditions, e.g. uphill (1)
- Mechanical advantage through gears (1) makes it easier/faster to pedal (1)

Q9b.

The driven gear will speed up/increase in speed (1 mark).

Q9c.

It allows the driver and driven gears to rotate in the same direction (1 mark).

Q10a.

12:48 (1); simplified to 1:4 (1).

Q10b.

$40 \div 10 = 4$ rotations (1 mark). Only acceptable answer.