

Design & Technology

Eduqas GCSE

The functions of mechanical devices

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. Which type of motion is a repeated back and forth movement in a straight line?

- A** Oscillating
- B** Reciprocating
- C** Rotary

Q2. Which mechanism changes rotary motion into linear motion?

- A** Rack and pinion
- B** Bell crank
- C** Pulley and belt

Q3. In a wheelbarrow the load is between the fulcrum and the effort. What class of lever is it?

- A** First class
- B** Second class
- C** Third class

Q4. What is the purpose of an idler gear between a driver gear and a driven gear?

- A** To make the driven gear turn faster
- B** To increase the force on the driven gear
- C** To make the driver and driven gears turn in the same direction

Q5. A driver gear has 20 teeth and the driven gear has 60 teeth. What is the gear ratio?

A 3 : 1

B 1 : 3

C 40 : 1

Q6. A lever lifts a load of 800N with an effort of 200N. What is its mechanical advantage?

A 0.25

B 4

C 600

Q7. An electric bicycle has many moving parts and converts different types of motion when in use.

Q7a. Using examples of other products, complete the table below by naming a product that uses each of the motions listed. **(3 marks)**

Motion	Product
Linear	
Reciprocating	
Oscillating	

Q7b. A bicycle brake system uses a bell crank lever. State the function of a bell crank lever. **(1 mark)**

Q8. An automata toy uses a cam mechanism to make a figure move.

Q8a. State the function of the cams on the automata toy. **(1 mark)**

Q8b. Describe the motion produced by a pear-shaped cam. **(2 marks)**

Q9. The table below shows information about a see-saw.

	Value
Load	300 N
Effort	400 N
Distance moved by the load	0.50 m
Distance moved by the effort	0.50 m

Q9a. Calculate the mechanical advantage of the see-saw. Show all workings. **(2 marks)**

Q9b. Calculate the velocity ratio of the see-saw. Show all workings. **(2 marks)**

Q9c. Explain the role of the fulcrum in the see-saw. **(1 mark)**

Q10. This question is about a bicycle.

Q10a. The rider of a bicycle turns the pedal crank 36 times in 30 seconds. Calculate the speed of the pedal crank in rpm (revolutions per minute). Show all workings. **(2 marks)**

Q10b. The bicycle's gear system has a rear gear with 12 teeth and a front gear with 48 teeth. Calculate the ratio of the gears used on the bicycle. Show all workings. **(2 marks)**

Q10c. Using the word bank (Fulcrum, Force, Lever, Load), complete the statement: "The handbrake on a bicycle is a and the point at which the brake handle pivots is a" **(2 marks)**

Q11. A LEGO merry-go-round uses a gear mechanism. The handle turns the drive gear, which has 32 teeth. The driven gear has 16 teeth.

Q11a. Calculate the gear ratio. Show all workings. **(2 marks)**

Q11b. If the handle rotates three times, calculate how many full rotations the merry-go-round will make. Show all workings. **(2 marks)**

Q11c. Using an example of a named product, explain the motion of a rack and pinion gear. **(3 marks)**

Q12. The driven wheel of an electric bicycle's gear system has 10 teeth and the driver wheel has 40 teeth.

Q12a. State how many rotations the driven gear makes if the driver gear rotates once. **(1 mark)**

Q12b. The diameter of the bicycle's wheel is 60cm. Calculate the distance in metres the electric bicycle will travel after ten rotations. Show all workings. **(3 marks)**

Q13. A modern record player turns a record on a turntable.

Q13a. State the meaning of rpm. **(1 mark)**

Q13b. Records can be played at 33rpm or 45rpm. State which record speed would take longer to play. **(1 mark)**

Q13c. Calculate the number of times a 45rpm record will rotate in 4 minutes. Show all workings. **(2 marks)**

Q13d. The turntable is driven by a motor using a rubber belt. The driver pulley on the motor has a diameter of 20mm and the driven pulley on the turntable has a diameter of 180mm. Calculate the velocity ratio of the driven pulley. Show all workings. **(2 marks)**

Q13e. Describe the differences between a simple gear train and a pulley and belt drive. **(4 marks)**

Answers

Q1. B

Q2. A

Q3. B

Q4. C

Q5. A

Q6. B

Q7a.

One mark for one product that correctly uses each motion. For example:

- Linear: a sliding drawer/door, automatic doors, a train, lifts, an adjustable desk
- Reciprocating: a sewing machine needle, a bicycle pump, a piston, a door bell ringer, a saw, cam toys
- Oscillating: a swing, a clock pendulum, an electric toothbrush

Q7b.

A bell crank changes the direction of a motion, e.g. around corners (1).

Q8a.

1 mark for: to create up and down movement, or converts rotary motion into linear (reciprocating) motion.

Q8b.

Must describe a pear-shaped cam, not other shapes. For example:

- A pear-shaped cam creates a sudden rise and fall (1), followed by a long period where the follower does not move (1)
- The follower stays still (dwells) for about half of the cam's rotation (1), and rises and falls during the other half (1)

Q9a.

Mechanical advantage = load ÷ effort = 300N ÷ 400N (1) = 0.75 (1).

Q9b.

Velocity ratio = distance moved by effort $\div$ distance moved by load = $0.50\text{m} \div 0.50\text{m}$ (1) = 1 (1).

Q9c.

The fulcrum is the pivot point around which the lever turns (1).

Q10a.

- $36 \div 30 = 1.2$ revolutions per second (1)
- $1.2 \times 60 = 72$ rpm (1)

Q10b.

$12 : 48$ (1) = $1 : 4$ (1). Credit any appropriate approach.

Q10c.

The handbrake on a bicycle is a lever (1) and the point at which the brake handle pivots is a fulcrum (1).

Q11a.

Either method accepted: driven $\div$ driver = $16 \div 32$ (1) = $1 : 2$ (1); or driver $\div$ driven = $32 \div 16$ (1) = $2 : 1$ (1).

Q11b.

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

Q11c.

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

Q12a.

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

Q12b.

One mark for each correct step. Either method is credited:

- Method 1: $10 \times 4 = 40$ rotations (1); circumference = $\pi \times 0.6\text{m} = 1.89\text{m}$ (1); $1.89\text{m} \times 40 = 75.6\text{m}$ (accept 75 to 76m) (1)
- Method 2: $10 \div 4 = 2.5$ rotations (1); circumference = $\pi \times 60\text{cm} = 188.5\text{cm}$ (1); $10 \times 188.5 = 1885\text{cm} = 18.85\text{m}$ (1)

Q13a.

Revolutions per minute (accept rotations) (1).

Q13b.

33rpm (1).

Q13c.

$45\text{rpm} \times 4$ (1) = 180 rotations (1).

Q13d.

Velocity ratio = diameter of driven pulley $\div$ diameter of driver pulley = $180\text{mm} \div 20\text{mm}$ (1) = 9 or 9 : 1 (1).

Q13e.

Up to 2 marks for two differences simply stated. An additional two marks if they are described and/or compared.

Simple gear train	Pulley and belt drive
Driver and driven shafts rotate in opposite directions	Shafts can rotate in the same or opposite directions
Distance between input and output shafts is limited	Shafts can be separated by a greater distance
An engagement drive (teeth mesh)	A friction drive
Cannot tolerate misalignment	Can tolerate a small amount of misalignment

Lubrication required; more expensive to maintain	Little or no lubrication; limited maintenance, so cheaper
Not affected by small temperature changes	Belt can stretch as temperature rises, and belt slip can occur
Shafts connected by rigid links	Shafts connected by a flexible element (belt)