

# Angular motion, torque and balance

AP Physics 1 (algebra-based) · Test answers (mark scheme)

Award method marks even when the final number is wrong, and allow follow-through from earlier values. Deduct a mark once for a missing unit. For written answers accept any wording that contains the key physics idea in the marking note.

**Level:** AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 5

## Question 1 Definitions (2 marks)

- a. Torque is the turning effect of a force about an axis,  $\tau = r F \sin \theta$ ; unit newton metre (N m).
- b. The net force is zero and the net torque about any axis is zero.

Marking: one mark per part.

## Question 2 Unit conversions (2 marks)

- a.  $120 \times 2\pi \div 60 = \mathbf{12.6 \text{ rad/s}}$  ( $4\pi \text{ rad/s}$ ).
- b.  $0.75 \times 2\pi = \mathbf{4.7 \text{ rad}}$  ( $3\pi \div 2$ ).

Marking: one mark per part.

## Question 3 Wheel speeding up (3 marks)

- a.  $\alpha = 18 \div 6.0 = \mathbf{3.0 \text{ rad/s}^2}$ .
- b.  $\theta = \frac{1}{2} \times 3.0 \times 6.0^2 = 54 \text{ rad}$ ;  $54 \div 2\pi = \mathbf{8.6 \text{ revolutions}}$ .

Marking: (a) 1 mark; (b) 1 mark for  $\theta$  in radians, 1 mark for conversion.

## Question 4 Spanner torque (3 marks)

- a.  $\tau = 0.35 \times 45 \times \sin 30^\circ = 0.35 \times 45 \times 0.50 = \mathbf{7.9 \text{ N m}}$ .
- b.  $F = \tau \div r = 7.875 \div 0.35 = \mathbf{22.5 \text{ N}}$ .

Marking: (a) 1 mark substitution, 1 mark answer; (b) 1 mark.

## Question 5 Is the plank balanced? (3 marks)

- a. Left:  $5.0 \times 9.81 \times 0.60 = 29.4 \text{ N m}$ . Right:  $3.0 \times 9.81 \times 1.0 = 29.4 \text{ N m}$ . They are equal.

- b. Right:  $4.0 \times 9.81 \times 1.0 = 39.2 \text{ N m}$ . Net =  $39.2 - 29.4 = \mathbf{9.8 \text{ N m clockwise}}$  (the right side goes down).

Marking: (a) 1 mark; (b) 1 mark for the new torque, 1 mark for result with direction.

### Question 6 Long handle (2 marks)

For a given force the torque is  $\tau = r F$ , so a longer handle gives a larger torque. The force needed for a given torque is smaller when the lever arm is longer.

Marking: 1 mark for  $\tau = rF$  with a longer  $r$ ; 1 mark for the smaller force required.

### Question 7 Beam and cable (3 marks)

- a.  $T \times 1.6 = 6.0 \times 9.81 \times 0.80$ , so  $T = \mathbf{29 \text{ N}}$  (29.4 N).  
b. Vertical equilibrium: hinge force =  $58.9 - 29.4 = \mathbf{29 \text{ N upward}}$ .

Marking: (a) 1 mark equation, 1 mark answer; (b) 1 mark.

### Question 8 Paragraph argument (2 marks)

The statement is incomplete. Zero net force means the centre of mass does not accelerate, but the object can still rotate if the net torque is not zero. Two equal and opposite forces applied at different points are an example: the net force is zero but the torque makes the object spin. Both the net force and the net torque must be zero.

Marking: 1 mark for the idea that torque also matters; 1 mark for a valid example or explanation.