**Q1.** The diagram below shows an electric two-wheeled vehicle and driver.

(a) The vehicle accelerates horizontally from rest to 27.8 m $s^{-1}$ in a time of 4.6 s. The mass of the vehicle is 360 kg and the rider has a mass of 82 kg.

(i) Calculate the average acceleration during the 4.6 s time interval.
Give your answer to an appropriate number of significant figures.

acceleration = ..... m $s^{-2}$

**(2)**

(ii) Calculate the average horizontal resultant force on the vehicle while it is accelerating.

resultant force = ..... N

**(2)**

(b) State and explain how the horizontal forward force on the vehicle has to change for **constant** acceleration to be maintained from 0 to 27.8 m $s^{-1}$.

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**(3)**

(c) The electric motors drive both wheels of the vehicle.

Add labelled force arrows to the diagram to show the horizontal forces acting on the vehicle when it is moving at a constant speed.

**(2)**

(d) The vehicle now accelerates to a constant speed of 55 m $s^{-1}$. The useful power output of the motors is 22 kW at this speed.

Calculate the horizontal resistive force acting on the vehicle.

horizontal resistive force = ..... N

**(2)**

**(Total 11 marks)**

**Q2.** A lead ball of mass 0.25 kg is swung round on the end of a string so that the ball moves in a horizontal circle of radius 1.5 m. The ball travels at a constant speed of 8.6 m $s^{-1}$.

(a) (i) Calculate the angle, in degrees, through which the string turns in 0.40 s.

angle ..... degree

**(3)**

(ii) Calculate the tension in the string.
You may assume that the string is horizontal.

tension ..... N

**(2)**

(b) The string will break when the tension exceeds 60 N.
Calculate the number of revolutions that the ball makes in one second when the tension is 60 N.

number of revolutions .....

**(2)**

(c) Discuss the motion of the ball in terms of the forces that act on it. In your answer you should:

- explain how Newton's three laws of motion apply to its motion in a circle
- explain why, in practice, the string will not be horizontal.

You may wish to draw a diagram to clarify your answer.

The quality of your written communication will be assessed in your answer.

**(6)**
**(Total 13 marks)**

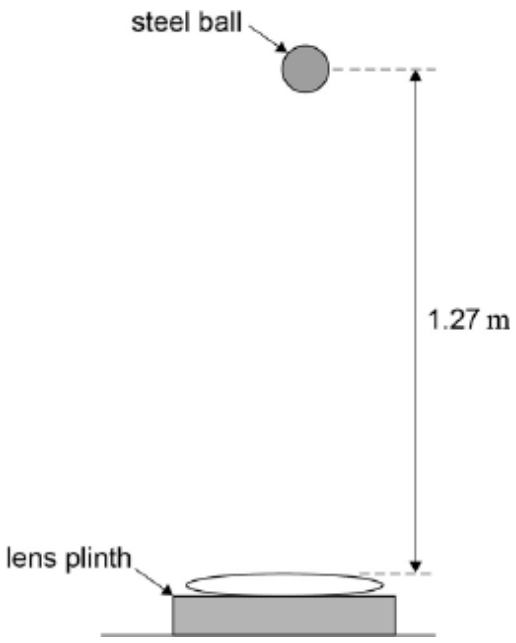
**Q3.** Spectacle lenses can be tested by dropping a small steel ball onto the lens, as shown in the figure below, and then checking the lens for damage.

A test requires the following specifications:

diameter of ball = 16 mm

mass of ball = 16 g

height of drop = 1.27 m




(a) Calculate the density of the steel used for the ball.

density = .....kg $m^{-3}$

**(3)**

(b) In a test the ball bounced back to a height of 0.85 m.

Calculate the speed of the ball just before impact.

speed = .....m $s^{-1}$

**(2)**

(c) Calculate the speed of the ball just after impact.

speed = m .....m $s^{-1}$

**(2)**

(d) Calculate the change in momentum of the ball due to the impact.

momentum = m ..... kg m $s^{-1}$

**(2)**

(e) The time of contact was 40 ms. Calculate the average force of the ball on the lens during the impact.

average force = ..... N

**(2)**

(f) Explain, with reference to momentum, why the test should also specify the material of the plinth the lens sits on.

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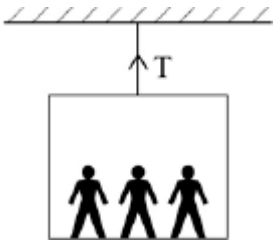
**(2)**
**(Total 13 marks)**

**Q4.** A lift and its passengers with a total mass of 500 kg accelerates upwards at 2 m $s^{-2}$ as shown. Assume that $g$ = 10 m $s^{-2}$.




What is the tension in the cable?

**A** 1000 N ⬭

**B** 4000 N ⬭

**C** 5000 N ⬭

**D** 6000 N ⬭

**(Total 1 mark)**

**Q5.** Which of the following statements is correct?

The force acting on an object is equivalent to

**A** its change of momentum. ⬭

**B** the impulse it receives per second. ⬭

**C** the energy it gains per second. ⬭

**D** its acceleration per metre.

**(Total 1 mark)**