**0 4** Spectacle lenses can be tested by dropping a small steel ball onto the lens, as shown in **Figure 3**, and then checking the lens for damage.

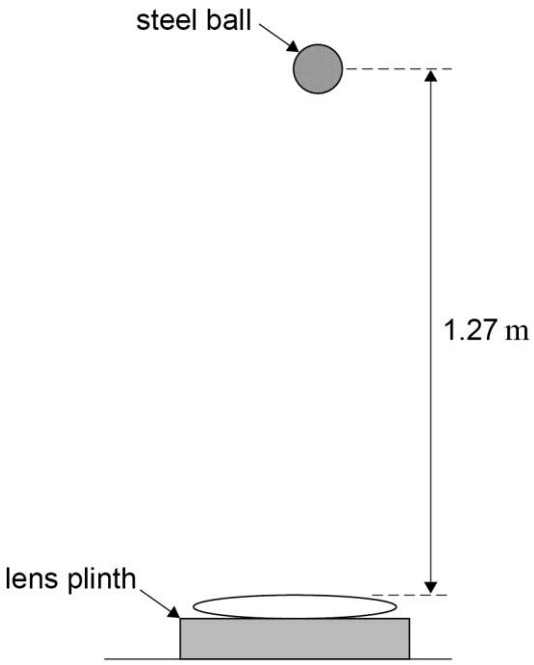
**Figure 3**

A test requires the following specifications:

diameter of ball = 16 mm

mass of ball = 16 g

height of drop = 1.27 m




**0 4 . 1** Calculate the density of the steel used for the ball.

**[3 marks]**

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

**0 4 . 2** In a test the ball bounced back to a height of 0.85 m.

Calculate the speed of the ball just before impact.

**[2 marks]**

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

**0 4 . 3** Calculate the speed of the ball just after impact.

**[2 marks]**

speed = _____ $m\ s^{-1}$

**0 4 . 4** Calculate the change in momentum of the ball due to the impact.

**[2 marks]**

momentum = _____ $kg\ m\ s^{-1}$

**0 4 . 5** The time of contact was 40 ms. Calculate the average force of the ball on the lens during the impact.

**[2 marks]**

average force = _____ N

**0 4 . 6** Explain, with reference to momentum, why the test should also specify the material of the plinth the lens sits on.

**[2 marks]**

_____

_____

_____

_____

**0 6** If lengths of rail track are laid down in cold weather, they may deform as they expand when the weather becomes warmer. Therefore, when rails are laid in cold weather they are stretched and fixed into place while still stretched. This is called pre-straining.

The following data is typical for a length of steel rail:

| | |
|---|---|
| Young modulus of steel = | $2.0 \times 10^{11}$ Pa |
| cross sectional area of a length of rail = | $7.5 \times 10^{-3}$ m$^2$ |
| amount of pre-strain = | $2.5 \times 10^{-5}$ for each kelvin rise in temperature the rail is expected to experience. |

A steel rail is laid when the temperature is 8 °C and the engineer decides to use a pre-strain of $3.0 \times 10^{-4}$.

**0 6 . 1** Calculate the tensile force required to produce the pre-strain in the rail required by the engineer.

**[3 marks]**

tensile force = _____ N

**0 6 . 2** Calculate the elastic strain energy stored in a rail of unstressed length 45 m when pre-strained as in part 6.1.

**[2 marks]**

elastic strain energy = _____ J

**Question 6 continues on the next page**

**0 6 . 3** Calculate the temperature at which the steel rail becomes unstressed.

**[2 marks]**

temperature = _____ °C

**0 6 . 4** Explain why the engineer does not use the highest observed temperature at the location of the railway track to determine the amount of pre-strain to use.

**[2 marks]**

_____

_____

_____

_____

**END OF QUESTIONS**