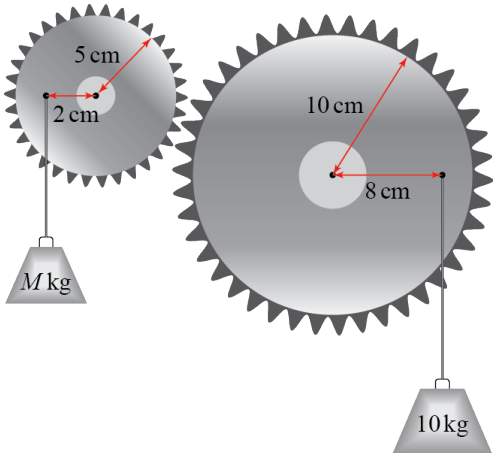
SECTION B: MECHANICS J

Answer ALL questions.

4.4 Two interlocking gears are in equilibrium. The gear on the right has a radius of 10 cm and has a loop 8 cm from the centre. The loop is to the right of, and level with the centre of the gear. A 10 kg mass hangs from the loop. The other gear has a radius of 5 cm and a loop 2 cm from the centre. The loop is to the left of, and level with the centre of the gear. A mass *M* kg hangs from the left loop.

Figure 4



Find the value of *M*. **(10 marks)**

5.1 An object rests on a rough surface and is pushed horizontally with force of 6 N. The mass of the object is 5 kg and the coefficient of friction between the object and the surface is 0.3.

a Draw a diagram showing all the forces acting on the object. Describe each of the forces using words and calculate their values. **(6 marks)**

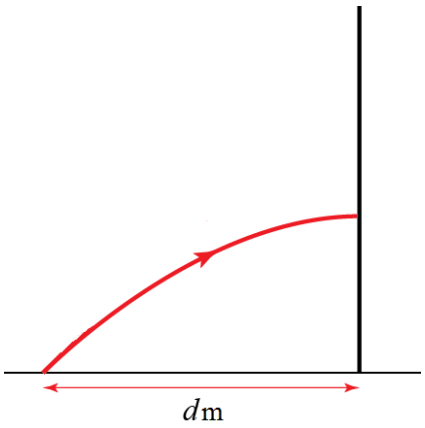
b The horizontal force acting on the object is increased to *P* N. Find the largest value of *P* for which the object does not slip. **(3 marks)**

6.2 A ball, modelled as a particle moving freely under gravity, is launched at 2 m s^{-1} from the origin at angle 45° above the horizontal.
(In this question, take g = 10 m s^{-2})

a Find the coordinates of the particle when it is at its maximum height. **(10 marks)**

On another occasion, the projectile is again is launched at 2 m s^{-1} from the origin at angle 45° above the horizontal. It travels a horizontal distance *d* m before hitting a vertical wall and then falling straight to the ground.

Figure 2



b Find the maximum height attained if $d = 0.1$. Give your answer in cm. **(5 marks)**

c Describe a possible limitation of this model. **(1 marks)**

7.2 Three forces, $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$, act on a circular lamina of radius 5 cm. The origin is at the centre of the lamina.

$\mathbf{F}_1 = \begin{pmatrix} 2 \\ 0 \end{pmatrix}$ N acts at the point $\begin{pmatrix} 1 \\ 1 \end{pmatrix}$ cm

$\mathbf{F}_2 = \begin{pmatrix} 3 \\ 0 \end{pmatrix}$ N acts at the point $\begin{pmatrix} -2 \\ 3 \end{pmatrix}$ cm

$\mathbf{F}_3 = \begin{pmatrix} f \\ 0 \end{pmatrix}$ N acts at the point $\begin{pmatrix} -3 \\ -3 \end{pmatrix}$ cm.

The net force on the lamina is zero.

a Find the value of f. **(2 marks)**

b Find the total moment about the origin. Give your answer in N m. **(4 marks)**

8.1 The position of a particle is **r** metres. Initially **r** = **i**. The velocity of the particle at time t seconds is **v** m s^{-1} where $\mathbf{v} = t\,\mathbf{i} + 3t^2\,\mathbf{j}$

a Find **r** in terms of t. **(3 marks)**

b Find the acceleration of the particle when $t = 4$. **(4 marks)**

c Find the position of the particle when it is 1 m from the x-axis. **(2 marks)**