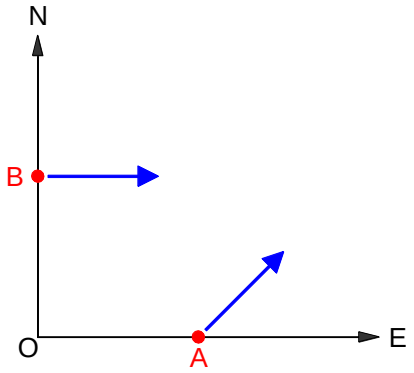
Submission deadline: Friday 12 April 2024 (6 pm) – Teaching Week 8

Coursework should be submitted via Blackboard in one PDF file. It may be word-processed or handwritten and scanned. **It must be your own individual work; you should not confer with others or use essay sites or AI tools**. No marks will be given if working is not shown or a scan is illegible. Marks will be deducted for multiple or non-PDF files, unnecessary padding, untidiness, units missing in final answers.

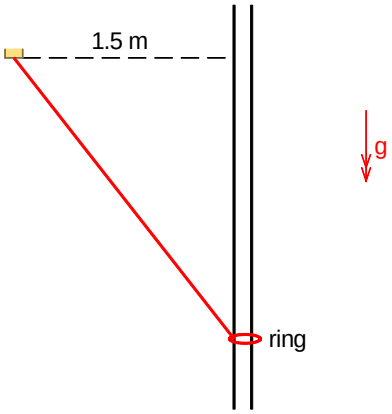
Question 1 (10 marks)



Particles A and B are launched simultaneously from rest at distances 100 m respectively east and north of the origin. Particle A has acceleration 2 m s^{-2} in a north-eastward direction and particle B has acceleration 4 m s^{-2} in an eastward direction.

Find the shortest distance between the particles in the subsequent motion.

Question 2 (15 marks)



A ring of mass 0.6 kg can move along a vertical, frictionless pole. The ring is tethered to a point 1.5 m from the pole by a light elastic string of natural length 1.5 m and elastic modulus 12 N. The ring is initially released from rest a distance 2.85 m below the level of the tether point.

(a) Determine the initial direction of motion (i.e. up or down) the pole.

(b) Find the maximum distance from the start point in the subsequent motion.

(c) If the smooth pole is replaced with a rough version, find the minimum coefficient of friction between pole and ring that will prevent motion.

NOTE: feel free to use an (accurate) graphical or numerical solution – but *not* an automatic root finder – for part (b) if necessary.

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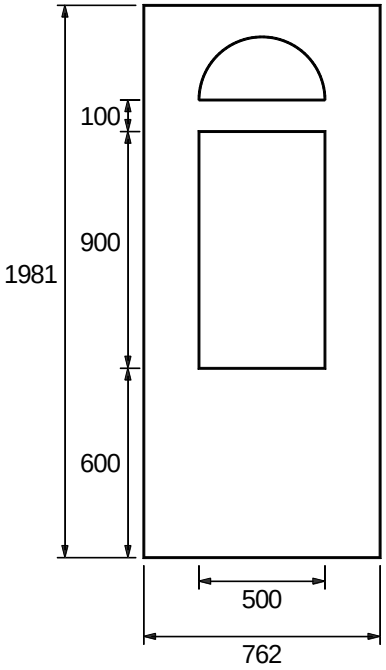
Question 3 (15 marks)



A thin solid-wood door being prepared for glazing has rectangular and semi-circular cut-outs as shown in the diagram. (All distances in mm.)

(a) Find the position of the centre of mass.

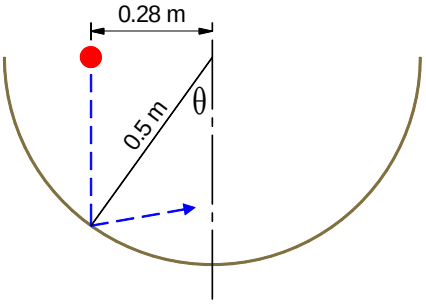
(b) Find the radius of gyration about an axis along the lowest side of the door.

(c) If the door topples without slipping about this lowest side, find its angular velocity as it hits the floor.

Data: for a semi-circular lamina of radius R:

- the centroid is distance $\frac{4}{3\pi}R$ from its straight edge;
- the radius of gyration about its straight edge is $R/2$.

Question 4 (10 marks)



A small ball is dropped into a smooth hemispherical bowl of radius 0.5 m from a point level with the top of the bowl and distance 0.28 m from the symmetry axis. The coefficient of restitution between ball and bowl is 0.3.

(a) Find the angle θ marked in the diagram.

(b) Find the speed with which the ball hits the bowl.

(c) Find the speed with which the ball rebounds from the bowl.