L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

INTERMEDIATE MATRICULATION LEVEL
2026 FIRST SESSION

SUBJECT:	**Applied Mathematics**
DATE:	11th May 2026
TIME:	4:00 p.m. to 7:05 p.m.

Directions to candidates

Attempt **ALL** questions. There are 10 questions in all.

The marks carried by each question are shown at the end of the question.

The total number of marks for all the questions in the paper is 100.

Graphical calculators are **not** allowed.

Scientific calculators can be used, but all necessary working must be shown.

A booklet with mathematical formulae is provided.

In this paper, ***i***, ***j*** are unit vectors along the *x*- and *y*- axes of a Cartesian system.

(take $g = 10\ \text{ms}^{-2}$)

1. A square *ABCD* of sides of length 1 m lies in the *x*-*y* plane with its vertex *A* at the origin, with sides *AB* and *AD* lying along the positive *x*-axis and *y*-axis respectively. The side *CD* is produced to *E* so that *DE* = *CD*. Unit vectors acting along the positive *x*-axis and *y*-axis are denoted by ***i*** and ***j*** respectively.

   Forces of magnitudes 2 N, $3\sqrt{2}$ N, 4 N and $2\sqrt{2}$ N act along *AB*, *AC*, *DA* and *AE* respectively in the direction indicated by the order of the letters. A fifth force reduces the system to equilibrium.

   a) Express the five forces in ***i, j*** notation. (6)

   b) Find the cartesian equation of the line of action in which the fifth force acts. (4)

   (Total: 10 marks)

2. A uniform metal rod *AB* of length 4 m and mass 15 kg is smoothly hinged at *A* to a vertical wall. The rod is held in a horizontal position by a rope fixed at the end *B* of the rod. The other end of the rope is fixed to a point on the wall vertically above *A* so that the rope makes an angle of 30° to the horizontal. A lamp of mass 30 kg is suspended from *B*.

   a) Sketch the free body diagram. (4)

   b) Find the tension in the rope. (3)

   The breaking tension in the rope is 2 kN. It is required to hang an additional piece of equipment of mass 90 kg from the rod.

   c) Find the greatest possible distance from *A* at which this can be hung without the rope breaking. (3)

   (Total: 10 marks)

Please turn the page.

3. A ladder of length 4 m and mass of 15 kg leans against a rough wall so that the ladder is at 70^o to the horizontal. The ladder remains at rest with its base on the rough horizontal ground. The coefficient of friction at the top (wall) and bottom (ground) of the ladder are 0.6 and 0.25 respectively.

   A man of mass 80 kg climbs up the ladder at distance *S* along the ladder before the ladder starts to slip.

   a) Find the reactions and frictional forces acting on the wall and floor when in limiting equilibrium. (8)

   b) Find how far up the ladder he can climb. (2)

(Total: 10 marks)

4. A uniform rectangular lamina *ABCD* has *AB = 7a* and *BC = 3a*. Points *H* and *E* are on the sides *BA* and *BC* respectively, such that *BH = 2a* and *BE = a*. The rectangle *BEFH* is removed from the plate.

   Show that the centre of mass of the remaining plate *AHFECD* is at a distance:

   a) $\frac{61}{38}\,a$ from *AB* and $\frac{123}{38}\,a$ from *AD*. (7)

   The plate *AHFECD* is now freely suspended from the point *A*.

   b) Find the angle *AD* makes with the downward vertical. (3)

(Total: 10 marks)

5. A ball is projected vertically upwards from ground level at a speed of 25 m/s. Find:

   a) how long after projection the ball is at a height of 20 m above the ground for the first time (4)

   b) the maximum height reached by the ball; (2)

   c) how long is the ball at least 20 m above ground level? (1)

   A ring is at a height of 2.25 m above the ground, and the ball passes through the ring.

   d) Find the speed of the ball when the ball passes through the ring. (3)

(Total: 10 marks)

6. A train engine, of mass 25,000 kg, pulls a truck of mass 10,000 kg along a railway line. The frictional resistance to the motion of the engine and truck is constant and of magnitude 50 N per 1,000 kg. When the train travels horizontally the tractive force exerted by the engine is 26 kN. Calculate:

   a) the acceleration of the train engine and the truck; (3)

   b) the tension in the coupling between the engine and truck. (3)

   The engine and truck now start to climb a slope whose inclination to the horizontal is α, where $\sin\alpha = 1/70$, and the frictional resistances remain the same. At a certain instant the engine and truck are moving up the slope with a speed of 10 m/s and acceleration of 0.6 m/s^2.

Calculate, at the instant:

c) the tractive force exerted by the engine; (2)

d) the power developed by the engine. (2)

(Total: 10 marks)

7. A parcel of mass 6 kg rests on a rough horizontal floor. The coefficient of friction between the parcel and the floor is 0.2. The parcel is pulled across the floor by a rope which is inclined at 20^o to the horizontal. The tension in the rope is constant and has a magnitude of 50 N. Find:

a) the frictional force opposing the motion; (4)

b) the work done by the tension moving the parcel a distance of 15 m. (2)

The parcel is initially at rest, find:

c) the speed of the parcel when it has moved 15 m. (4)

(Total: 10 marks)

8. Particles *A* and *B* have masses of 0.80 kg and 0.65 kg respectively. The two particles are approaching each other moving in opposite directions along the same horizontal straight line with speeds of 7 m/s and 5 m/s respectively. The coefficient of restitution between the particles is 4/5. After the first collision the direction of motion of *B* is reversed. Particle *B* then collides for a second time with a fixed vertical wall at right angles. The coefficient of restitution between *B* and the wall is 2/3. Find:

a) the speeds of *A* and *B* after the first collision; (8)

b) the speed of *B* after the second collision with the wall and show that *B* will collide with *A* again. (2)

(Total: 10 marks)

9. A conical pendulum consists of an inelastic string *AB* of length 2 m, fixed at *A* on one end and with a particle of mass *3m* attached at the lower end *B*. The mass is moving in a horizontal circle, the string is at an angle of 30^o to the downward vertical, and the tension in the string is 17 N.

a) Calculate the value of *m*. (6)

b) Given that the string breaks if the tension exceeds 48 N, find the greatest number of revolutions per minute the particle can attain. (4)

(Total: 10 marks)

10. A golf ball is hit from a point *O* on horizontal ground and moves freely under gravity. The horizontal and vertical components of the initial velocity are *4u* m/s and *3u* m/s respectively. The ball hits the horizontal ground at a point whose distance from *O* is 100 m.

a) Show that $u = \frac{5\sqrt{15}}{3}$. (5)

b) Show that the highest point of the path of the ball is 18.75 m above the ground. (2)

c) Find the speed of the ball 3 s after the ball has been hit. (3)

(Total: 10 marks)