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MINISTRY OF SECONDARY EDUCATION

TEACHERS' RESOURCE UNIT
REGIONAL BRANCH FOR THE NORTH WEST

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The Teachers' Resource Unit and the Regional Inspectorate of Pedagogy in collaboration with MTA	SUBJECT CODE NUMBER 0775	PAPER NUMBER 3
GENERAL CERTIFICATE OF EDUCATION REGIONAL MOCK EXAMINATION	SUBJECT TITLE FURTHER MATHEMATICS	
ADVANCED LEVEL	2	

Time Allowed: TWO and a half hours
INSTRUCTIONS TO CANDIDATES

Mobile phones are **NOT ALLOWED** in the examination room.

Answer ALL EIGHT questions

For your guidance, the appropriate mark for each part of a question is indicated in brackets.

You will be marked on your ability to use good English, to organize information clearly and to use specialist vocabulary where appropriate.

In calculations, you are advised to show all the steps in your working, giving your answer at each stage.

You are reminded of the necessity for good English and orderly presentation in your answers.

1. The forces F_1 and F_2 , where $F_1 = (-8\mathbf{i} + 8\mathbf{j} - 4\mathbf{k})N$ and $F_2 = (-4\mathbf{i} - 4\mathbf{j} - 2\mathbf{k})N$, act through the point A with position vector $(\mathbf{i} - 2\mathbf{j} - 3\mathbf{k})m$. A third force $F_3 = (18\mathbf{i} - 6\mathbf{j} + 9\mathbf{k})N$ acts through the point B with position vector $(-\mathbf{i} - 4\mathbf{j} - 4\mathbf{k})m$

i) Show that the system of the three forces F_1 , F_2 , and F_3 is equivalent to a single force F and find F (10marks)

Find, also,

ii) the work done by F in moving a particle from B to A. (3marks)

iii) the magnitude of the moment of \vec{F} about the origin. (2marks)

2. A particle moves with constant angular velocity ω round the curve with polar equation

$$r = a(1 - 4 \sin \theta), \quad a > 0$$

Find,

i) the maximum speed of the particle and the polar coordinates of the point at which this speed is maximum. (8marks)

ii) the transverse component of the acceleration of the particle. (3marks)

3.i) Find, as a series of ascending powers of $(x + 1)$, up to and including the term in $(x + 1)^4$, an approximate solution of the differential equation

$$\frac{d^2y}{dx^2} - 4x \frac{dy}{dx} + 2y = 0, \text{ given that}$$

$$y = 2 \text{ and } \frac{dy}{dx} = -1 \text{ when } x = -1. \quad (6\text{marks})$$

ii) Use your solution to find the value of y when $x = -1.2$. (2marks)

iii) Hence, using the approximations

$$h^2 \left(\frac{d^2y}{dx^2} \right)_n \cong y_{n+1} - 2y_n + y_{n-1} \quad \text{and} \quad 2h \left(\frac{dy}{dx} \right)_n \cong y_{n+1} - y_{n-1}$$

and a step length of 0.2, approximate the value of y when $x = -0.6$ (5marks)

iv) Find, also, an estimate for $\int_{-1}^{-0.6} y dx$, using Simpson's rule with three ordinates. (2marks)

(work throughout to 3 decimal places).

4. A smooth sphere A of mass $2m$ moving with velocity $(3\mathbf{i} + 4\mathbf{j})ms^{-1}$ impinges obliquely on another smooth sphere B of same radius but of mass $3m$ and which is moving with velocity $(2\mathbf{i} - \mathbf{j})ms^{-1}$. At the instant of collision, the line joining the centres of A and B is parallel to the vector \mathbf{i} . Given that the coefficient of restitution between A and B is $\frac{2}{3}$,

i) find the speed of A after collision. (8marks)

ii) show that A is deflected by the impact through an angle θ , where $11 \tan \theta = 2$. (4marks)

5.a) A discrete random variable X has a probability mass function P given by

$$P(X = x) = \begin{cases} kx & , \text{ for } x = 1, 2, 3, 4 \\ k(8 - x) & , \text{ for } x = 5, 6, 7 \\ 0 & , \text{ otherwise} \end{cases}$$

Find

i) the value of the constant k .

(2marks)

- ii) $P(3 < X \leq 6)$. (2marks)
iii) the mean of X . (2marks)
iv) the mean of $Y = 4X - 5$. (2marks)
b) A random sample of 8 articles is taken from a large batch of manufactured articles and the batch is accepted if fewer than 3 defective articles are found in the batch. Given that 15% of the articles in the batch are defective, find, correct to 3 significant figures, the probability that the batch is accepted. (3marks)

6. A particle of mass m is projected vertically downwards in a medium which exerts a resisting force of magnitude kv^2 per unit mass, where v is the speed of the particle and k is a positive constant. Given that $2u$ is the theoretical maximum speed of the particle as it falls,

i) show that $k = \frac{g}{4u^2}$. (4marks)

The particle is now projected vertically upwards with speed u in the same medium.

ii) Find the greatest height reached by the particle above its point of projection. (6marks)

7. An elastic string of natural length $4a$ is fixed at one end to a point O . It hangs vertically and carries at its other end, a particle of mass $2m$. In the position of equilibrium, the length of the string is $5a$.

Find,

i) the modulus of elasticity of the string (3marks)

ii) the period of small vertical oscillations of the particle when it is pulled downward from its equilibrium position and then released. (4marks)

8. Show, by integration, that the moment of inertia of a uniform thin rod AB of mass $3m$ and length $4a$ about an axis, through one end and perpendicular to the plane of the rod, is $16ma^2$ (5marks)

The rod is free to rotate in a vertical plane about a smooth horizontal axis through its end A .

Find

i) the radius of gyration of the rod about an axis through A . (2marks)

ii) the period of small oscillations of the rod about its position of stable equilibrium. (6marks)

iii) Hence, determine the length of the equivalent simple pendulum. (2marks)

END