UNIVERSITY OF NAIROBI

SECOND SEMESTER EXAMINATIONS - 2013/2014

FIRST YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN ENGINEERING

FCE 164 : CIVIL ENGINEERING
FEB 114 : ENVIRONEMENTAL AND BIOSYSTEMS ENGINEERING
FGE 174 : GEOSPATIAL ENGINEERING
FEE 112 : ELECTRICAL ENGINEERING
FME 174 : MECHANICAL ENGINEERING

APPLIED MATHS 1B

DATE: JANUARY 7, 2014 TIME: 8.30AM – 10.10AM

INSTRUCTIONS:

- Answer question ONE any TWO other questions.
- Use $g = 9.81\ m/s^2$.

Question One (30 marks)

a) A force of $\left(2\hat{i}+7\hat{j}\right)$N acts on a body of mass 5kg for 10 seconds. The body was initially moving with a constant velocity of $\left(\hat{i}-2\hat{j}\right)$ m/s. Find the final velocity of the body in vector form, and hence obtain its final speed. (4 marks)

b) A frequency distribution on the number of copper plugs sold by a manufacturing company over a period of 20 weeks was prepared as follows:

No. of copper plugs ('000's)	6 – 10	10 – 14	14 – 18	18 – 22	22 - 26
No. of weeks	1	3	8	6	2

Determine the lowest and the highest number of copper plugs sold during the middle 50% of this time period. (6 marks)

c) State and prove the work-kinetic energy principle. (4 marks)

d) An object of mass 2 kg is moving in a circle of radius 2m. At a given instant the object has a speed of 3m/s and an angular acceleration of 2 rad/s. Find the magnitude of the net force on the object at this instant. (5 marks)

$3.6 = \omega\sqrt{A^2 - x^2}$ $\quad \omega^2$

$\left(\frac{3.6}{\omega}\right)^2 = A^2 - x^2$ $\quad \frac{12.96}{\omega^2} = A^2 - 2500$

$\omega^2(A^2 - 2500) = 12.96$

e) A particle moves with simple harmonic motion about a mean position O. When particle is 50 cm from O, its speed is 3.6 m/s and when it is 120 cm from O, its speed 1.5 m/s. Find the amplitude and periodic time of motion. (5 marks)

f) When a die is rolled and a coin (with heads and tails) tossed, find the probabilities obtaining :

i) Tails and an even number

ii) A number greater than 3.

iii) Heads or a 3 given that the number rolled on the die was odd.

(6 marks)

Question Two (20 marks)

a) The frequency distribution below shores the marks scored by students in a certain college.

Marks	0 – 6	6 – 12	12 – 18	18 – 24	24 - 30
No. of students	4	d	12	8	e

i) If the median and mode of the marks were 15 and 14 respectively, determine the values of d and e.

ii) What would be the percentile rank of a student who scored 18 marks?

(8 marks)

b) Given that $\sum_i x_i^2 f_i = 36$, $\sum_i x_i f_i = 10$ and $\sum_i f_i = 6$ determine the value of

$$T = \frac{1}{10}\sum_i (x_i - 3)^2 f_i.$$

(3 marks)

c) A recent study by the school of Engineering revealed that 23 percent of students graduating with a BSc in Engineering select public service. Suppose we select a sample of 15 recent graduates.

i) What is the probability that exactly two select public service?

ii) What is the probability that at most three select public service?

iii) How many of the sample of 15 graduates would you expect to select public service?

(5 marks)

d) The number of messages sent to a computer bulletin board is a Poisson random variable with a mean of 5 messages per hour.

i) What is the probability that 5 messages are received in 1 hour?

ii) What is the probability that less than two messages are received in half an hour?

(4 marks)

Question Three (20 marks)

a) Prove that the torque about the origin of a coordinate system is equal to the time rate change of angular momentum. (4 marks)

b) Two billiard balls, assumed to have identical mass, collide in a perfectly elastic collision. Ball A is heading East at 12 m/s. Ball B is moving West at 8 m/s. Determine the post-collision velocities of ball A and ball B. (8 marks)

c) Find the impulse developed by a force given by

$$\bar{F} = 4t\hat{i} + (6t^2 - 2)\hat{j} + 12\hat{k} \text{ from } t=1 \text{ to } t=2.$$ (4 marks)

d) A shaft carrying a load of moment of inertia 8 kgm^2 revolves at a speed of 600 rev/min, and is engaged by means of a disk clutch with a shaft on the same axis having a moment of inertia of 12 kgm^2. If the second shaft is initially at rest, find:

i) The final speed of rotation of the two shafts together after slipping has ceased.

ii) The time of slip if the torque is constant at 200 Nm during slipping.

(4 marks)

Question Four (20 marks)

a) Define Simple Harmonic Notion. (2 marks)

A particle is executing simple harmonic motion in a straight line with period T and amplitude A. The particle has velocity v when at a distance x from the equilibrium position. Show that

$$vT = 2\pi\sqrt{A^2 - x^2}.$$ (4 marks)

b) A particle of mass 200g is attached to a light spring of natural length 40 cm and stiffness 50 N/m. The particle is allowed to hang reitically in equilibrium.

i) Find the extension of the spring in this position the spring is now pulled down 3 cm and released from rest.

ii) Find the length of the spring as a function of time.

(8 marks)

c) A particle executes simple harmonic motion with an amptitude of 3.00 cm. At what displacement from the midpoint of its motion does its speed equal one-half of its maximum speed. (6 marks)

Question Five (20 marks)

a) A constant force $\bar{F} = (-2\hat{i} + \hat{j})N$ acts on a particle as it moves along a straight wire from point A, position vector $(2\hat{i} - \hat{j})$m, to point B, position vector $(-\hat{i} + 3\hat{j})$m in 4 seconds. Find the average rate at which $\bar{F}$ is working. (4 marks)

b) Describe the conservation of mechanical energy. (2 marks)

A particle of mass 4 kg is suspended from a fixed point O by a light inextensible string of length 1m. It is projected from its lowest point with a horizontal speed of 6 m/s When the particle makes an angle of 60^0 with the vertical, find

i) the speed of the particle

ii) the tension in the string. (6 marks)

c) A block of mass 3 kg starts at rest at a height of h = 43 cm on a plane that has an angle of inclination of $\theta=35^o$ with respect to the horizontal. The block slides down the plane, and upon reaching the bottom, then slides along a horizontal surface. The coefficient of kinetic friction of the block on both surfaces is $\mu=0.25$. How far does the block slide along the horizontal surface before coming to rest? (8 marks)

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$v = \omega\sqrt{A^2 - x^2}$

$\frac{50}{120} \quad \frac{3.6}{1.5}$

$3.6 = \omega\sqrt{A^2 - 50^2} \qquad \left(\frac{1.5}{\omega}\right)^2 = A^2 - 120^2$

$3.6 = \omega \qquad A^2 = \frac{3.25}{\omega} + 120^2$

$\left(\frac{3.6}{\omega}\right)^2 = A^2 - 50^2$

$\frac{12.96}{\omega^2} = A^2 - 50^2 \qquad \frac{12.96}{\omega^2} + 50^2 = \frac{3.25}{\omega^2} + 120^2$

$\frac{12.96}{\omega^2} + 50^2 = A^2 \qquad \frac{12.96}{\omega^2} - \frac{3.25}{\omega^2} = 120^2 - 50^2$

$\frac{10.71}{\omega^2} = 11900$

$\omega = 0.03$

$A^2 = \frac{3.25}{0.03} + 120^2$

$A = 120.3$