THE MOMBASA POLYTECHNIC UNIVERSITY COLLEGE

(A Constituent College of Jkuat)

Faculty of Applied & Health Sciences

DEPARTMENT OF MATHEMATICS & PHYSICS

UNIVERSITY EXAMINATION FOR BACHELOR OF SC/TEC/ENG IN AUTOMOTIVE, BUILDING & CIVIL ENGINEERING & COMPUTER TECHNOLOGY

SPH 2170/APS 4101: PHYSICS I/PHYSICS FOR ENGINEERS I

SPECIAL/SUPPLEMENTARY EXAMINATION
SERIES: FEBRUARY/MARCH 2012
TIME: 2 HOURS

Instructions to Candidates:
You should have the following for this examination
- Answer booklet

This paper consists of **FIVE** questions
Answer question **ONE (COMPULSORY**) and any other **TWO** questions
This paper consist of **FOUR** printed pages

Take:
Speed of light in a vacuum=3.0×10^8 m/s
Gravitational acceleration, g=9.81 m/s^2

$$\eta = 1.00$$

Refractive index of air,

Question 1 (30 Marks)

a) Distinguish between the following:
   i) A dot and a cross product of two vectors. (2 marks)
   ii) Coefficient of static friction and coefficient of kinetic friction. (2 marks)

b) Derive the **three** equations that describe uniformly accelerated motion. (8 marks)

c) Use dimensional analysis to test the validity of the following expression of period T in a simple pendulum. l is the length of the string and g is the measure of gravitational field strength.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

(3 marks)

d) Three vectors are given by $\vec{A} = 3\mathbf{i} + 3\mathbf{j} - 3\mathbf{k}$, $\vec{B} = -\mathbf{i} + 4\mathbf{j} + 2\mathbf{k}$ and $\vec{C} = 2\mathbf{i} + 2\mathbf{j} + \mathbf{k}$. Find:

i) The cross product $\vec{A} X \vec{B}$. (3 marks)

ii) The component of $\vec{A} X \vec{B}$ along $\vec{C}$. (4 marks)

e) State the conditions necessary for a body to be in equilibrium. (2 marks)

f) State the effect of doubling the amplitude of a simple harmonic oscillator on:

i) The period (1 mark)
ii) The spring constant (1 mark)
iii) The total energy (1 mark)
iv) The maximum acceleration. (1 mark)

g) State two conditions necessary for total internal reflection to occur. (2 marks)

Question 2 (20 marks)

a) Explain what is meant by Brewster's angle. (2 marks)

b) Light is incident from air on glass with an index of refraction of 1.5. Find the angle at which the reflected be fully polarized. (3 marks)

c) A projectile is fired from a level ground at an angle θ above the horizontal.

i) Prove that the ratio of the maximum height H to the range is given by $H/R = 1/4 \tan\theta$ (4 marks)

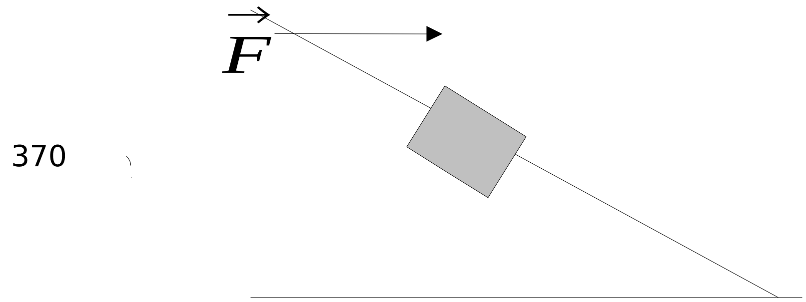
ii) For what angle θ does $H = R$? (2 marks)

iii) If the initial velocity of the projectile has vertical and horizontal components of 40 m/s and 20 m/s respectively, determine its time of flight and the range (6 marks)

d) A wheel rotates at a constant angular velocity ω about a fixed axis. What is the state of equilibrium of the wheel? Explain your answer. (3 marks)

Question 3 (20 marks)

a) A 5.0 kg block on an inclined plane with an elevation angle of 37^0 is acted on by a horizontal force $\vec{F}$ with magnitude 50 N.



The coefficient of kinetic friction between the block and the plane is 0.30.

i) What is the acceleration of the block if is moving up the plane? (4 marks)

ii) When the horizontal force stops acting after half a second, how far up the plane does the block go if it has an initial speed of 4m/s along the plane? (5 marks)

b) Distinguish between stress and strain on a material. (2 marks)

c) Sketch a graph of stress (y axis) against strain of a material. Discuss the nature of the graph. (5 marks)

d) A bar has dimensions 1 cm by 1 cm by 20 cm. It is subjected to a 10,000 N tension force along its cross section and it stretches by 0.01cm. Determine its Young's modulus. (4 marks)

<u>Question 4 (20 marks)</u>

a) Explain what is meant by linear expansivity of a material. (2 marks)

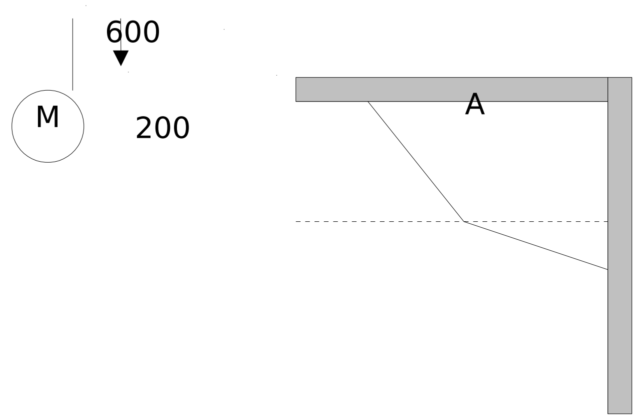
b) Briefly explain how temperature can be regulated using a bi-metallic strip. (3 marks)

c) Briefly describe the two types of measurement errors and state how each can be minimized (4 marks)

d) The system shown below is in equilibrium. If M=2.0kg, find the tension in string AB and string BC. (5 marks)

B

A C



e) The equation of a transverse wave traveling along a string is given by $y = (2.0mm)\sin[(20m^{-1})x - (600s^{-1})t]$. Find the:

i) Amplitude (1 mark)

ii) Frequency (1 mark)

iii) wavelength (1 mark)

iv) velocity of the wave (1 mark)

v) The maximum transverse speed of a particle in the string. (2 marks)

Question 5 (20 marks)

a) A wheel of radius 0.250m, which is moving initially at 43.0m/s, rolls to a stop in 225m. The wheel's rotational inertia is $0.155kgm^2$ about its central axis. Calculate the magnitudes of:

i) Its linear acceleration (3 marks)

ii) Its angular acceleration (2 marks)

iii) The torque about the central axis due to friction on the wheel (2 marks)

b) Show that the radial acceleration for a body undergoing circular motion with an angular velocity ω is given by $\bar{\mathbf{a}} = -\frac{v^2}{r}\bar{\mathbf{r}}$ (6 marks)

c) Suppose the co-ordinate of a particle of a particle moving along the x-axis is given as a function of time t by $x(t) = 7.8 + 9.2t - 2.1t^2$ where x is in metres and t is in seconds. Find

i) The average velocity between $t = 2$ and $t = 4$ seconds (3 marks)

ii) The velocity and acceleration at $t = 3$ seconds (4 marks)