UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF APPLIED PHYSICS AND ENGINEERING MATHEMATICS

MODULE: PHYSICS PH1AEET

DFC CAMPUS

JUNE EXAMINATION

DATE: 26/05/2016 **SESSION: 12:30 – 15:30**

ASSESSOR: **MR. MJ.MVELASE**

INTERNAL MODERATOR: **MR TG MATHE**

DURATION: 3 HOURS **MARKS: 100**

NUMBER OF PAGES: 5 PAGES, INCLUDING 1 INFORMATION SHEET

INSTRUCTIONS: CALCULATORS ARE PERMITTED (ONLY ONE PER STUDENT)
GIVE YOUR ANSWERS CORRECT TO TWO DECIMAL PLACES

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QUESTION 1: [44 Marks]

1.1. If $\vec{X} = \left(3\hat{i} - 5\hat{j} - 3\hat{k}\right)$ and $\vec{Y} = \left(2\hat{i} + 3\hat{j} - 4\hat{k}\right)$, Calculate

1.1.1. The sum of X and Y (03)

1.1.2. The difference of Y and X (04)

1.1.3. The scalar product of X and Y (05)

1.1.4. The vector product of X and Y (05)

1.2. The position vector of a comet's trajectory t seconds after release, is given in meters by: $\vec{r}(t) = 6t\,\hat{i} + \left(20t - 5t^2\right)\hat{j} + 9t\,\hat{k}$. After one seconds calculate, showing all your workings, its:

1.2.1. Velocity (04)

1.2.2. Speed (03)

1.2.3. Acceleration (03)

1.2.4. Displacement (02)

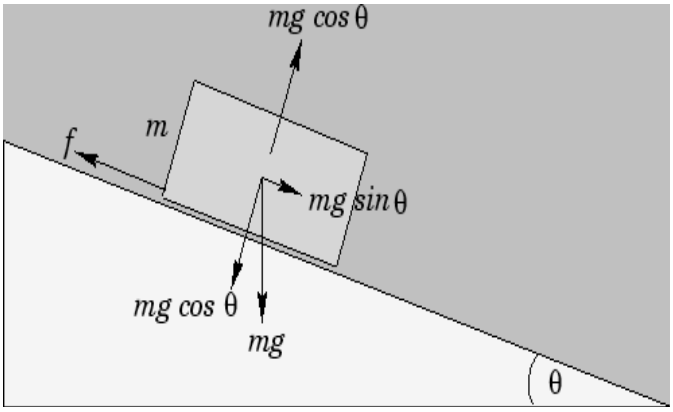
1.3. A particle of mass 2.0 kg moves with a uniform velocity $v = \left(3.0\,\hat{i} + 3.0\,\hat{j}\right) m.s^{-1}$.

At time *t,* the particle passes through the point (2.0 m, 3.0 m).
Calculate the magnitude and dir*ec*tion of the angular momentum at time *t.* (05)

1.4. Two balls collide in air. Ball A has a mass of 0.025 kg and is moving along the x-axis with a velocity of +5.5 $m.s^{-1}$. It makes a collision with ball B, which has a mass of 0.050 kg and is initially at rest. The collision is NOT head on.
After the collision, the two balls move apart with angles A (65º) and B (37º).
Calculate the speeds of the balls after the collision. (10)

QUESTION 2: [20 Marks]

2.1. Study the following diagram of the block lying on an inclined plane.
The resolving of all components has been done.



Prove that the coefficient of kinetic friction is $\mu_k = \tan\theta$ (05)

2.2. A 1500 kg car moving on a flat, horizontal road negotiates a curve. If the radius of the curve is 35.0 m and the coefficient of static friction between the tires and dry road is 0.523, calculate the maximum speed the car can have without skidding away from the road. (05)

2.3. An airplane propeller, 1.20 m in length, is rotating at 2000 rpm.

2.3.1. Calculate its angular velocity (03)
2.3.2. How long does it take the propeller to turn through an angle of 150^o? (03)
2.3.3. Calculate the tangential speed of the tip of the propeller? (02)
2.3.4. Calculate linear distance the tip covers in one second (02)

QUESTION 3: [10 Marks]

3.1. Calculate the de Broglie wavelength associated with an α-particle accelerated through a potential difference of 600 keV. Given $m_p = 1.67\times10^{-27}$ kg. (05)

[**NB**: mass of α-particle is about twice that of a proton]

3.2. One spectral line in the hydrogen spectrum has a wavelength of 650 nm. Calculate the energy difference of this photon (in electron volt). (05)

QUESTION 4: [26 Marks]

4.1. Scandium $^{44}_{21}Sc$ decays by emitting a positron. The nuclide that is the product of the decay is: (02)

A) $^{44}_{22}Ti$ B) $^{43}_{21}Sc$ C) $^{44}_{20}Ca$ D) $^{45}_{21}Sc$ E) $^{43}_{22}Sc$

4.2. Which of the following particles has the smallest mass?

A) Proton B) Electron C) Neutron D) Nucleus E). Nucleon (02)

4.3. The isotope of radium $^{226}_{88}Ra$ decays to $^{222}_{86}Rn$.

4. 3.1. What kind of nuclear decay is taking place? Support your statement. (02)

4. 3.2. Write down the decay equation in full. (03)

4.4 The alpha particle emitted by radium has energy of 12 MeV. Calculate the speed of the particle (05)

4.5. The energy released by the nuclear bomb that destroyed Hiroshima was equivalent to 12.4 kilotons of TNT. This is equivalent to 9.0×10^{26} MeV. Calculate the mass that was converted into energy in this explosion. (03)

4.6. What initial mass of $^{235}_{92}U$ is required to operate a 500 MW reactor for one year? Assume 40% efficiency and the energy released in the fission of one uranium atom is on average, 200 MeV. (09)

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USEFUL INFORMATION SHEET

$$h\nu = h\nu_o + K_E; \quad \frac{1}{\lambda} = R\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]; \quad N = \frac{m}{M} N_A$$

$$N = Noe^{-\lambda t}; \quad A = \lambda N; \quad A = A_o e^{-\lambda t}$$

$$\lambda = \frac{0.693}{t_{1/2}}; \quad c = f\lambda; \quad \lambda = \frac{h}{\sqrt{2meV}}$$

$$\Delta E = \frac{hc}{\lambda}; \quad E = mc^2; \; I = mr^2$$

$$s = r\theta; \quad v = r\omega; \; a = r\alpha; \; \omega = \frac{2\pi}{T} \quad f = \frac{1}{T};$$

$$\omega = \omega_o + \alpha t; \; \omega^2 = \omega^2{}_o + 2\alpha\theta; \quad \theta = \omega_o t + \frac{1}{2}\alpha t^2$$

$$v = v_0 + at; \; v^2 = v_0{}^2 + 2as; \; s = v_o t + \frac{1}{2}at^2$$

$$E_R = \frac{1}{2} I\omega^2; \quad E_T = \frac{1}{2} mv^2; \; E_{sp} = \frac{1}{2} kx^2; \; \tau = r_\perp F = I\alpha$$

$$L = mvr = I\omega; \; F = \frac{mv^2}{r} = ma = mg; \; f_k = \mu_k mg$$

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CONSTANTS

$R = 1.097 \times 10^7 \, m^{-1}$

$c = 3 \times 10^8 \, m.s^{-1}$

$h = 6.63 \times 10^{-34} \, Js$

$m_p = 1.67 \times 10^{-27} \, kg$

$m_e = 9.11 \times 10^{-31} kg$

$g = 9.8 \text{ m.s}^{-2}$

$e = 1.6 \times 10^{-19} C$

$G = 6.67 \times 10^{-11} \, Nm^2 kg^{-2}$

$N_A = 6.02 \times 10^{23}$

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