UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF APPLIED PHYSICS AND ENGINEERING MATHEMATICS

MODULE: PHYSICS PH1AEET

DFC CAMPUS

JULY EXAMINATION

DATE: 27 JULY 2016	**SESSION: 08:00-11:00**
ASSESSOR:	**MR. MJ.MVELASE**
INTERNAL MODERATOR:	**MR TG MATHE**
DURATION: 3 HOURS	**MARKS: 100**

NUMBER OF PAGES: 6 PAGES, INCLUDING 1 INFORMATION SHEET

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

SECTION A: LONGER QUESTIONS

QUESTION 1: [18 Marks]

Koeberg nuclear reactor in Cape Town uses ${}^{235}_{92}U$ as fuel. The collisions made by the fission products lead to high heat that produces the steam which in turn gives rise to the rotation of turbine. Suppose technicians want to service Unit 1, where a 18 kg turbine engine of radius 0.3 m, initially spinning at 25 000 rpm is located. If it takes 15 seconds for this turbine to stop. Calculate:

1.1. The angular deceleration of the turbine. (03)
1.2. The linear acceleration of the turbine. (03)
1.3. The moment of inertia of the turbine. (03)
1.4. The torque of the turbine. (03)
1.5. The angular momentum of the particle sitting on the edge of the turbine. (03)
1.6. How many turns does it make before coming to rest? (03)

QUESTION 2: [16 Marks]

The isotope of radium ${}^{14}_{6}C$ decays to ${}^{14}_{7}N$.

2.1. What kind of nuclear decay is taking place? Support your statement? (02)
2.2. Write down the decay equation in full. (03)

2.3. The electrical power output of a large nuclear reactor facility is 900 MW. It has 35% efficiency in converting nuclear power to electrical.

2.3.1. Calculate the thermal nuclear power output of in megawatts (03)
2.3.2. How many ${}^{235}_{92}U$ fission each second assuming each fission produces 200 MeV? (04)
2.3.3. Calculate the mass of ${}^{235}_{92}U$ used in one year of full-power operation (04)

SECTION B: MULTIPLE CHOICE QUESTIONS

1. What are the numbers of protons Z and neutrons N in the missing fragment of the following fission reaction? (Conserve charge and baryon number)

$${}^{1}_{0}n + {}^{235}_{92}n \rightarrow ? + {}^{140}_{55}Cs + 4\left({}^{1}_{0}n\right)$$

A. Z = 55 and N = 37 C. Z = 37 and N = 55 E. Z = 92 and N = 37

B. Z = 37 and N = 92 D. Z = 37 and N = 58 (3)

2. A gram is equal to:

A. 10^{-6} kg B. 10^{-3} kg C. 1 kg D. 10^{3} kg E. 10^{6} kg (3)

3. Possible units of angular momentum are

A. kg.m.s^{-1} B. kg.m^{2}.s^{-2} C. kg.m.s^{-2} D. kg.m^{2}.s^{-1} E. none of these (3)

4. In a decay scheme

$${}^{A}_{Z}P \rightarrow {}^{A}_{Z-1}P + ? + ?$$

The question marks should contain:

A. β^+ and n B. β^- and λ C. β^- and p D. β^+ and ν E. β^+ and β^- (3)

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

A. Proton B. Electron C. Neutron D. Nucleus E. Nucleon (3)

6. The following reaction: ${}^{1}_{0}n + {}^{235}_{92}n \rightarrow {}^{141}_{56}Cs + {}^{92}_{36}Kr + 3\left({}^{1}_{0}n\right) + 200\text{MeV}$

is called:

A. Fusion B. Fission C. alpha decay D. beta decay E. gamma decay (3)

7. The half-life of a radioactive sample is 5 min. The decayed sample in 20 min will be:

A. 93.75% B. 75% C. 25% D. 6.25% E. Invalid (3)

8. Which of the following is correct for the number of neutrons in the nucleus?

A. N = A – Z B. N = Z – A C. N = Z + A D. N = Z E. N = A (3)

9. Rubidium $^{83}_{37}Rb$ is a naturally occurring nuclide that undergoes beta-minus decay. The nuclide, which is the product of the decay, is:

A $^{87}_{38}Kr$ B. $^{88}_{37}Rb$ C $^{87}_{36}Kr$ D $^{83}_{38}Sr$ E $^{87}_{36}Sr$ (3)

10. Neodymium $^{144}_{60}Nd$ is a nuclide that undergoes alpha decay. The nuclide that is the product of the decay is:

A $^{148}_{62}Nd$ B $^{142}_{56}Ba$ C $^{140}_{55}Ba$ D $^{140}_{58}Ce$ E $^{146}_{64}Ce$ (3)

11. The nucleus $^{115}_{48}Cd$ after two successive beta decays will be:

A. $^{115}_{46}Pa$ B. $^{114}_{49}In$ C. $^{113}_{50}Sn$ D. $^{115}_{50}Sn$ E. $^{112}_{48}Cd$ (3)

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

A $^{44}_{22}Ti$ B $^{43}_{21}Sc$ C $^{44}_{20}Ca$ D $^{45}_{21}Sc$ E $^{43}_{21}Sc$ (3)

13. A uniform circular disk of radius *R* and mass *M* is rotating with angular speed ω about an axis, passing through its centre and inclined at an angle 60 degrees with respect to its symmetry axis. The magnitude of the angular momentum of the disk is,

A $\frac{\sqrt{3}}{4}\omega mr^2$ B $\frac{\sqrt{3}}{8}\omega mr^2$ C $\frac{\sqrt{7}}{8}\omega mr^2$ D $\frac{\sqrt{7}}{4}\omega mr^2$ E $\frac{\sqrt{5}}{9}\omega mr^2$ (3)

14. Possible units for the disintegration constant λ are

A. kg/s B. s/kg C. hour D. day^{-1} E. cm^{-1} (3)

15. Two cars are 150 kilometres apart and travelling toward each other. One car is moving at 60 km.h^{-1} and the other is moving at 40 km.h^{-1}. In how many hours will they meet?

A. 2.5 hours B. 2.0 hours C. 1.75 hours D. 1.5 hours E. 1.25 hours

16. One mile (mi) is equivalent to 1609 m so 55 mph is:

A. 15 m.s^{-1} B. 25 m.s^{-1} C. 66 m.s^{-1} D. 88 m.s^{-1} E. 1500 m.s^{-1} (3)

17. A particle moves along the x-axis from x_i to x_f. Which of the initial and final coordinates, give largest displacement?
A. x_i=4m, x_f=6m B. x_i=−4m, x_f=−8m C. x_i=−4m, x_f=2m D. x_i=4m, x_f=−2m
E. x_i=−4m, x_f=4m (3)

18. A car, initially at rest, travels 20 m in 4 s along a straight line with constant acceleration. The acceleration of the car is:
A. 0.4 m.s^{-2} B. 1.3 m.s^{-2} C. 2.5 m.s^{-2} D. 4.9 m.s^{-2} E. 9.8 m.s^{-2} (3)

19. A racing car traveling with constant acceleration increases its speed from 10 m.s^{-1} to 50 m.s^{-1} over a distance of 60 m. How long does this trip take?
A. 2.0s B. 4.0s C. 5.0s D. 8.0s E. Undefined time (3)

20. A car moving with an initial velocity of 25 m.s^{-1} north has a constant acceleration of 3 m.s^{-2} south. After 6 s its velocity will be:
A. 7 m.s^{-1} N B. 7 m.s^{-1} S C. 43 m.s^{-1} N D. 20 m.s^{-1} N E. 20 m.s^{-1} S (3)

21. At a location where g=9.80 m.s^{-2}, an object is thrown vertically down with an initial speed of 6 m.s^{-1}. After 5 s the object will have traveled:
A. 125 m B. 152.5 m C. 245 m D. 250 m E. 255 m (3)

22. Vectors $\vec{A}$ and $\vec{B}$ each have magnitude L. When drawn with their tails at the same point, the angle between them is 30°. The value of $\vec{A}.\vec{B}$=
A. Zero B. L^2 C. $\frac{\sqrt{3}}{2}L^2$ D. 2L^2 E. None of these (3)

USEFUL INFORMATION SHEET

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

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

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

$$\Delta E = E_2 - E_1 = \frac{hc}{\lambda}; \quad E = mc^2; \; I = mr^2$$

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

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

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

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

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

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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 m.s^{-2}

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

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

$N_A = 6.02 \times 10^{23}$ atoms/mol

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