UNIVERSITY OF JOHANNESBURG

DEPARTMENT OF PHYSICS (APK)

MODULE: PHYSICAL SCIENCES FOR FET 3A

CODE: PSFT03A

NOVEMBER EXAMINATION

DATE: 28 NOVEMBER 2016

	Student's Mark	Question's Mark
MCQ		20
Q 1		10
Q 2		10
Q 3		12
Q4		15
Q 5		15
Q 6		15
Total		100

FACULTY OF SCIENCE

EXAMINER/MODERATOR — **Mr. M Khwanda**
Prof. S Oyoo

TIME — 3 Hrs

MARKS — **100 MARKS**

INSTRUCTIONS: ANSWER ALL THE QUESTIONS IN THE SPACES PROVIDED

NUMBER OF PAGES: 13, INCLUDING COVER PAGE
REQUIREMENTS: SCIENTIFIC CALCULATOR, NO PROGRAMMABLE CALCULATORS ARE ALLOWED

Student Number									

ID Number													

Surname and Initials: _____

Contact Number: _____

Venue: _____

MCQ Answer sheet

1	2	3	4	5	6	7	8	9	10

Answer the multiple choice questions on the space provided on the first page.

1. A rigid body rotates about a fixed axis with a constant angular acceleration. Which one of the following statements is true concerning the tangential acceleration of any point on the body?

A) The tangential acceleration is zero m/s^2.

B) The tangential acceleration depends on the angular velocity.

C) The tangential acceleration is equal to the centripetal acceleration.

D) The tangential acceleration is constant in both magnitude and direction.

E) The tangential acceleration depends on the change in the angular velocity.

2. Complete the following statement: When a net torque is applied to a rigid object, it always produces a

A) constant acceleration.

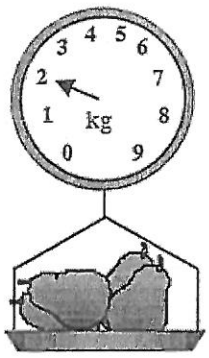
B) rotational equilibrium.

C) constant angular velocity.

D) constant angular momentum.

E) change in angular velocity.

3. In the produce section of a supermarket, five pears are placed on a spring scale. The placement of the pears stretches the spring and causes the dial to move from zero to a reading of 2.0 kg. If the spring constant is 450 N/m, what is the displacement of the spring due to the weight of the pears?



A) 0.0044 m

B) 0.0088 m

C) 0.018 m

D) 0.044 m

E) 0.088 m

4. Complete the following sentence: The operation of a hydraulic jack is an application of

A) Pascal's principle.

B) Bernoulli's principle.

C) Archimedes' principle.

D) irrotational flow.

E) the continuity equation.

5. Complete the following statement: Walls that separate a system from its surroundings and permit heat to flow through them are called

A) diathermal walls.

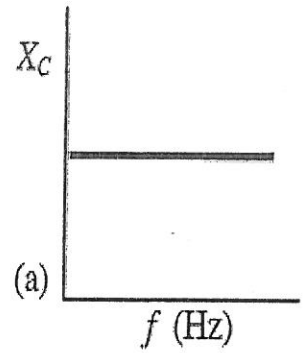
B) adiabatic walls.

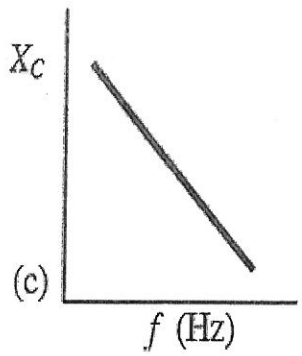
C) entropic walls.

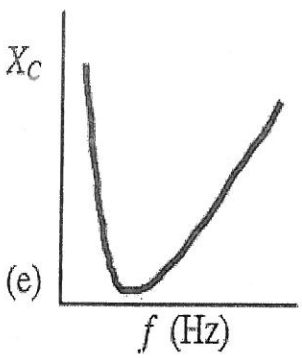
D) isobaric walls.

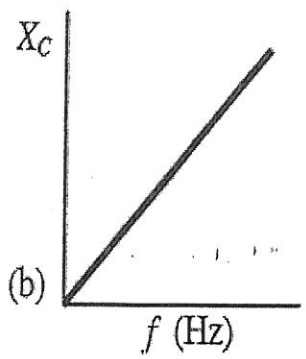
E) isochoric walls.

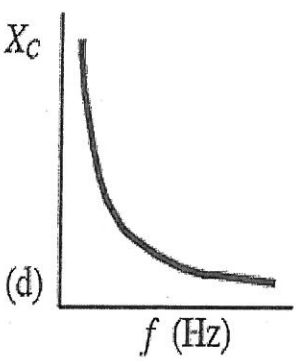
6. Which one of the following graphs illustrates how capacitive reactance varies with frequency?



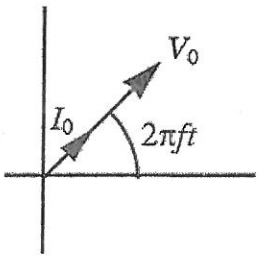


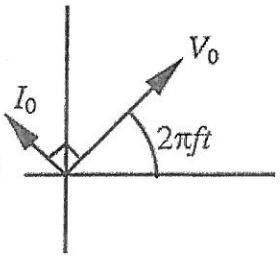


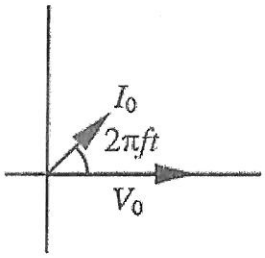


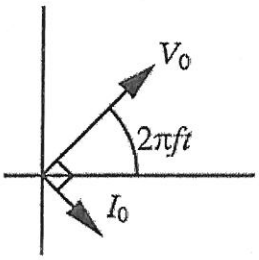


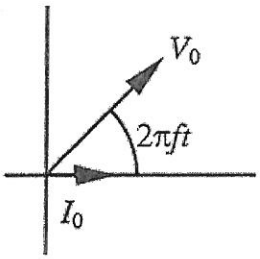
7. Which one of the following phasor models correctly represents a circuit comprised of only an inductor and an ac generator?

(a) 

(c) 

(e) 

(b) 

(d) 

8. Which one of the following systems would constitute an inertial reference frame?

A) a weather balloon descending at constant velocity

B) a rocket undergoing uniform acceleration

C) a roller coaster traveling around a corkscrew turn at constant speed

D) an orbiting space station

E) a rotating merry-go-round

9. Which one of the following is a consequence of the postulates of special relativity?

A) There is no such thing as an inertial reference frame.

B) Newton's laws of motion apply in every reference frame.

C) Coulomb's law of electrostatics applies in any reference frame.

D) The question of whether an object is at rest in the universe is meaningless.

E) The value of every physical quantity depends on the reference frame in which it is measured.

10. Which one of the following statements is a consequence of Special Relativity?

A) Clocks that are moving run slower than when they are at rest.

B) The length of a moving object is larger than it was at rest.

C) Events occur at the same coordinates for observers in all inertial reference frames.

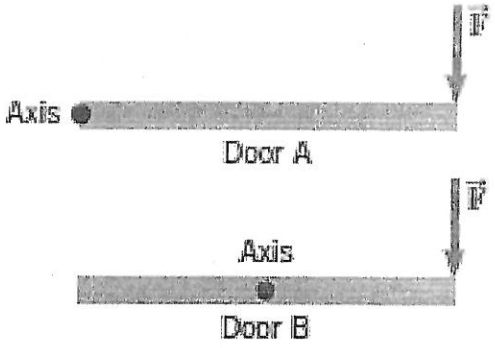
D) Events occur at the same time for observers in all inertial reference frames.

E) The speed of light has the same value for observers in all reference frames.

Question 1: Rotational Dynamics [10]

1.1 State two conditions for a rigid body to be in equilibrium. (2)

1.2 The drawing below shows the top view of two doors. The doors are uniform and identical. Door **A** rotates about an axis through its left edge, and door **B** rotates about an axis through its center. The same force is applied perpendicular to each door at its right edge, and the force remains perpendicular as the door turns. No other force affects the rotation of either door. Starting from rest, door A rotates through a certain angle in 3.00 s. How long does it take door B (also starting from rest) to rotate through the same angle? (8)



Question 2: Simple Harmonic Motion **[10]**

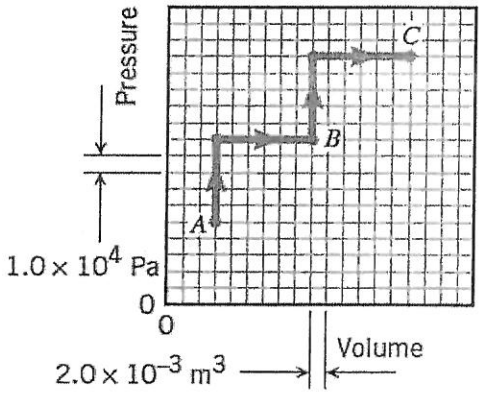
2.1 What is the significance of the minus sign on the equation of Hook's law, $Fx = - kx$? (2)

2.2 What are "elastic materials"? (2)

2.3 A helicopter is using a steel cable to lift a 2100-kg jeep. The unstretched length of the cable is 16 m, and its radius is 5×10^{-3} m. Using a suitable free-body diagram, calculate the amount the cable stretch when the jeep is hoisted straight upward with an acceleration of 1.5 m/s^2. (6)

Question 3: Thermodynamics **[15]**

3.1 The graph below represent pressure versus volume of a gas. Use the graph to answer the following questions:



3.1.1 Estimate the magnitude of the work done when the system changes from A to B to C along the path shown. (5)

3.1.2 Determine whether the work is done by the system or on the system. (2)

3.2 An engine has an efficiency e_1. The engine takes input heat of magnitude $|Q_H|$ from a hot reservoir and delivers work of magnitude $|W_1|$. The heat rejected by this engine is used as input heat for a second engine, which has an efficiency e_2 and delivers work of magnitude $|W_2|$. The overall efficiency of this two-engine device is the magnitude of the total work delivered $(|W_1| + |W_2|)$ divided by the magnitude $|Q_H|$ of the input heat. Find an expression for the overall efficiency e in terms of e_1 and e_2. (8)

Question 4: Electric circuits. **[15]**

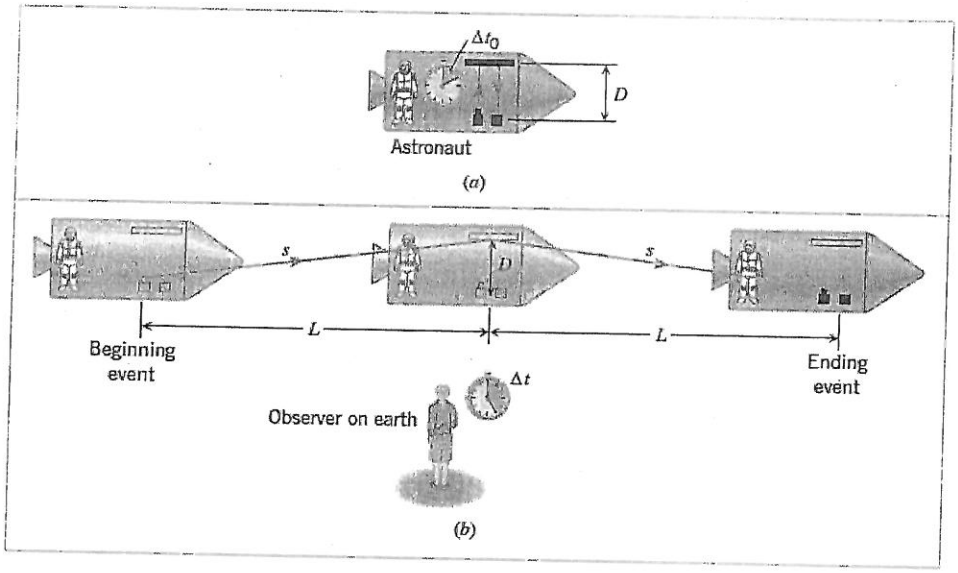
4.1 An AC series circuit has an impedance of 150 Ω, and the phase angle between the current and the voltage of the generator is Ø=-75°. The circuit contains a resistor and either a capacitor or an inductor. Calculate the resistance **R** and the capacitive reactance X_C or the inductive reactance X_L, whichever is appropriate. (4)

4.2 In a series circuit, a generator (1350 Hz, 15.0 V) is connected to a 16.0 Ω resistor, a 4.10 μF capacitor, and a 5.30-mH inductor. Calculate the voltage across each circuit element. (7)

4.3 Mention a condition for resonance frequency to occur and then show that the resonance frequency f_0 is given by: $f_0 = \frac{1}{2\pi\sqrt{LC}}$. (4)

Question 5: Special Relativity Theory **[15]**

5.1 State two postulate of special relativity theory and then use the following diagram to derive the equation for time dilation given by the following: $\Delta t = \frac{\Delta t_0}{\sqrt{1-\frac{v^2}{c^2}}}$. (10)



5.2 A spacecraft has a nonrelativistic (or classical) momentum whose magnitude is 2.6×10^{13} kg.m/s. The spacecraft moves at such a speed that the pilot measures the proper time interval between two events to be one-half the dilated time interval. Calculate the relativistic momentum of the spacecraft. (5)

5.3 An electron ($m = 9.109 \times 10^{-31}$ kg) is accelerated from rest to a speed of $v = 0.9995c$ in a particle accelerator. Determine the electron's (in millions of electron volts or MeV)

5.3.1 rest energy, (2)

5.3.2 total energy, and (2)

5.3.3 kinetic energy (2)

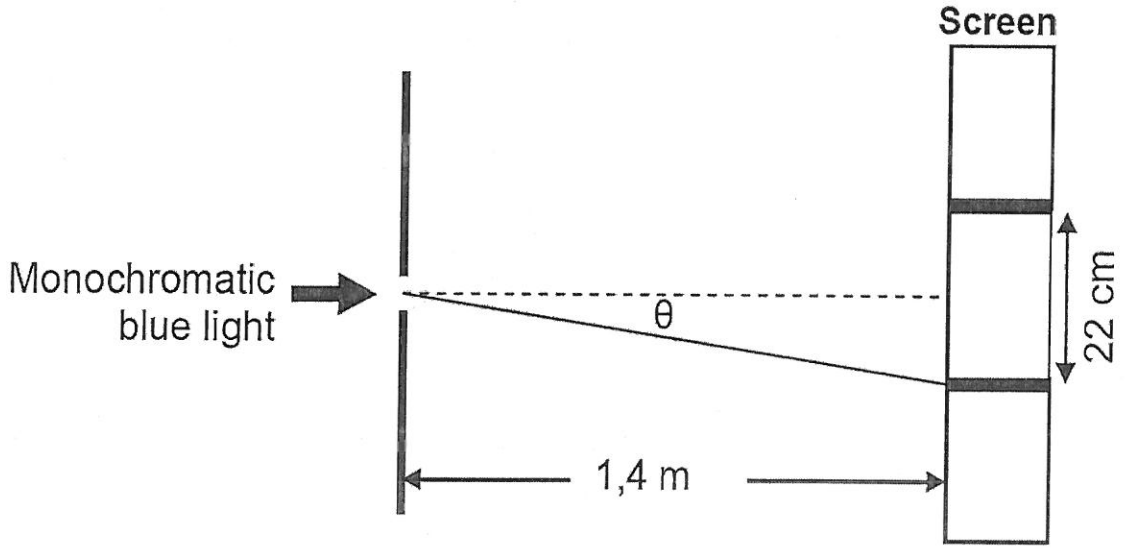
Question 6: Interference and the wave nature of light **[15]**

Learners use monochromatic blue light to investigate the difference between an interference pattern and a diffraction pattern.

6.1 Apart from the blue light and a screen, write down the name of ONE item that the learners will need to obtain an interference pattern. (2)

6.2 Briefly describe the interference pattern that will be observed on the screen. (2)

6.3 In one of their experiments they place the screen at a distance of 1.4 m from a single slit and observe a pattern on the screen. The width of the central bright band is measured as 22 cm. Calculate the:



6.3.1 Angle θ at which the first minimum will be observed on the screen (3)

6.3.2 The width of the slit used if the wavelength of the blue light is 470 nm (5)

6.4 The width of the central band INCREASES when the blue light is replaced with monochromatic red light. Explain this observation. (2)

THE END

USEFUL INFORMATION

$$\omega = \sqrt{\frac{k}{m}} \qquad E = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 + mgh + \frac{1}{2}kx^2 \qquad F = Y\left(\frac{\Delta L}{L_0}\right)A$$

$$X_C = \frac{1}{2\pi fC} \qquad X_L = 2\pi fL \qquad v_{rms} = I_{rms}Z \qquad \bar{P} = I_{rms}V_{rms}cos\emptyset$$

$$sin\theta = \frac{m\lambda}{d} \quad m = 0, 1, 2, 3, \ldots \qquad sin\theta = \frac{(m+\frac{1}{2})\lambda}{d} \quad m = 0, 1, 2, 3, \ldots \qquad sin\theta = m\frac{\lambda}{W} \quad m = 1, 2, 3, \ldots$$

$$L = L_0\sqrt{1 - \frac{v^2}{c^2}} \qquad p = \frac{mv}{\sqrt{1-\frac{v^2}{c^2}}} \qquad E = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} \qquad E_0 = mc^2$$