JOINT UNIVERSITIES PRELIMINARY EXAMINATIONS BOARD

JUNE 2020 EXAMINATIONS

JUPEB/017E

PHYSICS **SCI – J155** **Time Allowed: 3 Hours**

SECTION A: MULTIPLE CHOICE QUESTIONS

Answer all questions in this section.

Use the OMR answer sheet provided to answer the questions. Follow the instructions on the OMR sheet.

SECTION B: ESSAY QUESTIONS

Answer FOUR questions; ONE question from each course.

The following Constants are given.

Acceleration due to gravity	$g = 9.8\ m/s^2$
Atomic mass unit	$u = 931.5\ MeV = 1.661 \times 10^{-27}\ kg$
Avogadro's number	$N_A = 6.02 \times 10^{23}\ mol^{-1}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\ JK^{-1}$
Electron charge	$q = 1.6 \times 10^{-19}\ C$
Electron rest mass	$m_e = 9.11 \times 10^{-31}\ kg$
Electron volt	$eV = 1.6 \times 10^{-19} J$
Gravitational constant	$G = 6.7 \times 10^{-11}\ Nm^2kg^{-2}$
Molar gas constant	$R = 8.31\ JK^{-1}mol^{-1}$
Permeability of free space	$\mu_o = 4\pi \times 10^{-7}\ Hm^{-1}$
Permittivity of free space	$\varepsilon_o = 8.85 \times 10^{-12}\ Fm^{-1}$
Planck constant	$h = 6.63 \times 10^{-34}$ Js`
Proton rest mass	$m_p = 1.7 \times 10^{-27}\ kg$
Radius of the earth	$R = 6.4 \times 10^6\ m$
Speed of light in vacuum	$c = 3.0 \times 10^8\ ms^{-1}$
Stefan constant	$\sigma = 5.67 \times 10^{-8}\ W/(m^2k^4)$
Wien Constant	$a = 2.9 \times 10^{-3}\ mK$
$(4\pi\varepsilon_o)^{-1}$	$= 9.0 \times 10^9\ mF^{-1}$

SECTION A: MULTIPLE CHOICE QUESTIONS.

Answer ALL Questions.

1. The pressure of a confined fluid is measured reliably by which of the following devices?
   A. Manometer and Mercury-barometer.
   B. Thermometer and Mercury-barometer.
   C. Hydrometer and Manometer.
   D. barometer and Spectrometer.

2. The equation **a = 2 + 2t** represents the acceleration of a particle in a time t. Find the instantaneous velocity after 4s.
   A. $8ms^{-1}$
   B. $32ms^{-1}$
   C. $24ms^{-1}$
   D. $42ms^{-1}$

3. Which of the following statements is correct about an elastic collision?
   A. only the total momentum of the colliding objects is conserved.
   B. only the total kinetic energy is conserved.
   C. both of the momentum and total kinetic energy are conserved.
   D. neither momentum of the colliding bodies nor the total kinetic energy is recoverable.

4. A string with a force 80N has an extension of 0.05m. If it is used to shoot a stone of mass 20g, what is the velocity of the stone?
   A. 0.14 m/s
   B. 1.414 m/s
   C. 141.4 m/s
   D. 14.14 m/s

5. The reluctance of an object to start moving when at rest or stationary and its reluctance to stop once it starts moving is known as …
   A. inertia.
   B. weight.
   C. Reaction.
   D. Action.

6. Two blocks of masses $m_1 = 300$ g and $m_2 = 500$ g in contact with each other, rest on a table. The coefficient of friction between each block and the table is 0.4. What must be the value of the applied force if the blocks are to have an acceleration of 200 cm/s^2? (Take g = 9.8 m/s^2)
   A. 7.84 N
   B. 1.60 N
   C. 4.74 N
   D. 3.14 N

7. The magnitude of the mass of an object placed at the earth's North Pole is
   A. zero.
   B. greater at the pole than on earth surface.
   C. lesser at the pole.

D. of constant value.

8. Vectors A and B are said to be parallel if

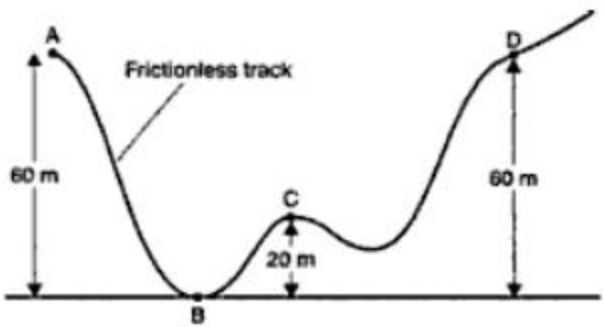
A. $A.B = 0$

B. $A.B = 90$

C. $|A \times B| = 90$

D. $|A \times B| = 0$

9. A truck of mass 150kg is released from rest at A and moves along the frictionless track as shown in the figure below. Calculate its maximum kinetic energy. ($g = 10\ ms^{-2}$)



A. 30kJ

B. 60kJ

C. 120kJ

D. 90kJ

10. Which of the following(s) is/are correct?

I. All fundamental quantities are scalar quantity

II. All derived quantities are scalar quantity

III. All fundamental quantities are vector quantity

IV. Not all derived quantities are vector quantity

A. I, II and III

B. II, III and IV

C. I, II and IV

D. I and IV only

11. A body is dropped from rest and allowed to fall freely from a given height under gravity. The kinetic energy at its half way is

A. little above half of its initial energy.

B. little below half of its initial energy.

C. half of its energy.

D. little above its energy.

12. The safety speed of a vehicle on a curve horizontal road is

A. μrg

B. $\sqrt{\mu rg}$

C. $\frac{\mu}{rg^2}$

D. $\mu^2 rg$

13. An aircraft of mass 2.0×10^4 kg lands on an aircraft-carrier deck with a horizontal velocity of $90ms^{-1}$. If it is brought to rest in a distance of 100 m, calculate the average retarding force acting on the plane.

A. -8.1×10^5 N

B. -4.1×10^1 N

C. -2.0×10^4 N

D. 2.0×10^6 N

14. Which of the following is a suitable expression for Poiseuille's equation for the flow of liquid through a tube?

A. $\frac{P}{4\eta L}x^2$

B. $\frac{P}{4\eta L}(a^2 - x^2)$

C. $\frac{P}{4\eta L}(x^2 + a^2)$

D. $\frac{P}{4\eta L}(x^2 - a^2)$

15. A small metal sphere with diameter 12mm is dropped into glycerin. The viscous force on the object is 3.2N. Calculate the coefficient of viscosity of the fluid if the terminal velocity of the object is $8ms^{-1}$.
    A. $1.57\ Ns/m^2$
    B. $2.81\ Ns/m^2$
    C. $3.54\ Ns/m^2$
    D. $4.42\ Ns/m^2$

16. Buttered paper is an example of
    A. a transparent object
    B. a translucent object
    C. an opaque object
    D. a luminous object

17. Determine the rate of radiant emission per m^2 from a black body at 25 ^0C.
    A. 396 W
    B. 447
    C. 445 W
    D. 430 W

18. In the longitudinal waves, the direction of vibration in medium of particle is
    A. perpendicular to the propagation of wave.
    B. parallel to the propagation of wave.
    C. different from each other.
    D. variable from time to time.

19. A body emits 60 cycles per second of a progressive wave travelling at 20m/s. What is the wavelength of the wave?
    A. 5.12m
    B. 0.33m
    C. 2.5m
    D. 0.50m

20. The following statements/expressions are false EXCEPT

A. a close system allows only the exchange of matter with the surrounding.

B. $dQ = dU - dW$

C. for a given mass of a gas, $C_p > C_v$

D. adiabatic change refers to change of pressure and temperature only.

21. Calculate the critical angle for a ray of light which is incident at a water-glass surface. $(n_w = 1.33, n_g = 1.5)$

A. 42°

B. 49°

C. 57°

D. 63°

22. If two objects are each in thermal equilibrium with a third object, then the two objects are in thermal equilibrium with each other. This is a statement of

A. Law of heat conservation.

B. Zeroth Law of Thermodynamics.

C. First law of Thermodynamics.

D. Law of thermal preservation.

23. The song of a bird with an intensity of 1.4×10^{-8} W/m^2 and frequency of 6.0 kHz is heard by a hunter in the woods. Calculate the displacement amplitude of the sound wave. (The density of air, $\rho = 1.20$ kg/m^3, speed of sound in air, v = 343 m/s).

A. 1.2×10^{-10} m

B. 2.2×10^{-10} m

C. 4.2×10^{-10} m

D. 7.4×10^{-10} m

24. Which of the following types of radiation has the longest wavelength?

A. Ultra-Violet

B. Radio waves

C. Light wave

D. Micro wave

25. A string whose linear density is 400 g/m under a tension of 55 N receives sinusoidal wave of frequency 8 Hz. Find the angular speed.

A. 50.3 rad/s

B. 40.4 rad/s

C. 30.8 rad/s

D. 25.1 rad/s

26. In a double-slit experiment the distance between the fringes on a screen was too small to measure. What would increase the distance between the fringes?

A. Increasing the distance between the light source and the slits.

B. Increasing the distance between the slits and the screen.

C. Increasing the distance between the slits.

D. Increasing the frequency of the light source.

27. A gas of volume 400 cm^3 at 27 ^0C is heated at constant pressure to a temperature 45 ^0C. What is its new volume?

A. 424 cm^3

B. 42.4 cm^3

C. 4.24 cm^3

D. 0.424 cm^3

28. Which of the following properties are **NOT** those of a suitable thermometric liquid?

I. It should be a good conductor of heat

II. It should be opaque

III Its expansion should be regular

IV. It should wet glass

V It should have a high melting point and low boiling point

A. I and II

B. I and III

C. II and III

D. IV and V

29. How many grams of water at 20°C must be added to 35g of ice at 0°C to melt it completely? (Specific heat capacity of water = $4.2\times10^{3}Jkg^{-1}K^{-1}$, Specific latent heat of fusion of ice = $3.4\times10^{5}Jkg^{-1}$)

A. 320.2g

B. 445.2g

C. 125.6g

D. 129.8g

30. The gas model which considers the gas molecules to be small particles which are far apart, and move randomly at high speed and colliding elastically is called . . .

A. The real gas theory.

B. The molecular gas theory.

C. The kinetic gas theory.

D. The atomic gas theory.

31. A capacitor stores 0.24 coulombs at 10 V. Calculate its capacitance.

A. 0.024 F

B. 0.12 F

C. 0.6 F

D. 0.8 F

32. The SI unit for magnetic flux is

A. Fluxon (Fl).

B. Weber (Wb).

C. Tesla (T).

D. Gauss (G).

33. An RLC circuit is used in a radio to tune into the Radio Lagos FM station broadcasting at 93.5Hz. The resistance is15 Ω and the inductance is 1.6 H. Calculate the capacitance used.

A. 1.8 μF

B. 2.5 μF

C. 3.8 μF

D. 5.0 μF

34. Which of the following is true of electrical conductors?
    A. They are materials in which some of the electrons are free electrons.
    B. They are materials in which none of the electrons are free electrons.
    C. They are materials in which all of the electrons are free electrons.
    D. They are materials in which some of the neutrons are free conductors.

35. A battery of e.m.f 2.50 V with an internal resistance 0.5 Ω is connected in series to a resistor of 10 Ω. Calculate the current flowing in the circuit.
    A. 2.38 A
    B. 0.238 A
    C. 23.8 A
    D. 0.023 A

36. The carriers of charge in a gas are
    A. electrons only.
    B. ions only.
    C. electrons and holes.
    D. electrons and ions.

37. The force between two charges is 120 N. If the distance between the charges is doubled, the magnitude of the force will be
    A. 60 N
    B. 30 N
    C. 40 N
    D. 15 N

38. A 200 turn coil having an axial length of 30 mm and a radius of 10 mm is pivoted in a magnetic field having a flux density of 0.8 T. If the coil carries a current of 0.5 S, calculate the torque acting on the coil.
    A. 4.8 Nm
    B. 0.48 Nm
    C. 0.048 Nm

D. 0.0048 Nm

39. The electric potential along an *x-axis* is given by the expression $V = ax - bx^2$, where a and b are constants. At what point on the *x-axis* is the electric field zero?
    A. $x = 0$
    B. $x = a/2b$
    C. $x = a/b$
    D. $x = 3\,a/2b$

40. The essential parts of an a.c. generator consists of the following EXCEPT
    A. Field magnet.
    B. Slip rings.
    C. Split rings.
    D. Brushes.

41. In an extrinsic semiconductor, electricity is conducted through
    A. Electrons.
    B. Holes.
    C. Electrons and holes.
    D. Electrons and proton.

42. A substance has a half-life of 5 minutes. After 10 minutes, the count rate was observed to be 500. What was its count at zero time?
    A. 100
    B. 200
    C. 2,000
    D. 5,000

43. One of the features of the nuclear fission process is that
    A. neutrons are not released.
    B. it leads to chain reaction.
    C. the sum of the masses of the reactants equals the sum of the masses of the products.
    D. its products are non-radioactive.

44. Calculate the maximum kinetic energy of liberated electrons when Caesium with a work function of 25×10^{-18}J is illuminated by light of frequency 8.6×10^{15} Hz.

A. 2.7×10^{-19} J

B. 6.4×10^{-19} J

C. 3.3×10^{-18} J

D. 5.4×10^{-18} J

45. The characteristic x-ray depends on

A. the electron energy.

B. tube voltage.

C. the electron wavelength.

D. the target.

46. A hydrogen atom is in its fourth excited state. Calculate the radius of the electron's Bohr orbit.

A. 1.32×10^{-9}m

B. 8.46×10^{-10}m

C. 2.65×10^{-10}m

D. 2.13×10^{-10}m

47. Find the charge on a stationary oil drop of mass 0.5 kg located at a distance 5 mm between two plates with potential difference 1000 V in an electric field.

A. 2.5×10^{-4} C

B. 2.5×10^{-5} C

C. 2.5×10^{5} C

D. 2.5×10^{4} C

48. An element and its isotopes only differ in the number of

A. Protons.

B. Neutrons.

C. Electrons.

D. Atomic number.

49. What is the de Broglie wavelength for an electron moving with a speed of $3.0 \times 10^6\ m/s$?

A. $2.43 \times 10^{-12}\ m$

B. $2.43 \times 10^{-10}\ m$

C. $2.43 \times 10^{-8}\ m$

D. $2.43 \times 10^{-6}\ m$

50. The electromagnetic radiation used in medicine is

A. hard x-ray.

B. soft x-ray.

C. cosmic ray.

D. gamma ray.

SECTION B: PHYSICS ESSAY QUESTIONS

Answer FOUR Questions; one Question from each Course.

PHY 001: MECHANICS AND PROPERTIES OF MATTER

1. (a) Briefly explain the following:
   i. Young's modulus;
   ii. Stiffness of elastic material. **[2 marks]**

(b) Figure 1 shows a graph of force against extension for a metal specimen.

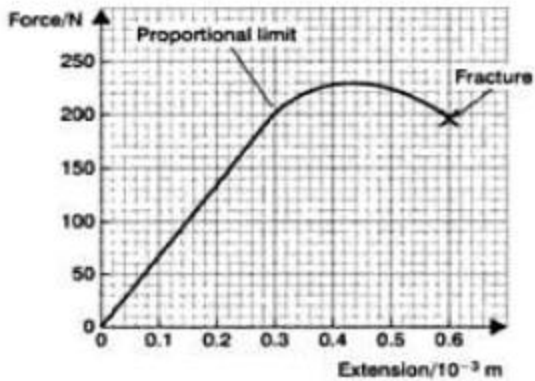


Figure 1

Calculate the:

i. force constant of the specimen;
ii. work done in stretching the specimen up to the proportional limit.

[3 marks]

(c) Two particles of mass 0.20kg and 0.30kg are placed 0.15m apart. A third particle of mass 0.050kg is placed between them on the line joining the first two particles. Calculate:

i. the gravitational force acting on the third particle if it is placed 0.050m from the 0.30kg mass;
ii. where along the line should it be placed for no gravitational force to be exerted on it?

[5 marks]

[Total = 10 marks]

2. (a) i. Define Unit Vector.

ii. State the work-energy theorem. **[3 marks]**

(b) A certain satellite is in circular orbit about the Earth at an altitude of 550km. If the satellite makes a revolution every 110minute, calculate:

i. its orbital speed;

ii. the centripetal acceleration. ($R_{earth} = 6.4 \times 10^6 m$) **[4 marks]**

(c) State without proof Bernoulli's equation for a tube flow with varying cross-sectional area. State each of the component and each of the parameters with the associated S.I unit. **[3 marks]**

[Total = 10 marks]

PHY 002: HEAT, WAVES AND OPTICS

3. (a) What is Diffraction Grating? **[2 marks]**

(b) Distinguish between the following:

i. Coherent sources and incoherent sources;

ii. Constructive interference and Destructive interference. **[4 marks]**

(c) Determine the angular positions of the first and second order maxima for light of wavelength 400 nm and 700 nm incident on a grating containing 10000 lines/cm. **[4 marks]**

[Total = 10 marks]

4. (a) i. List four characteristics of waves.

ii. Define linear magnification.

iii Write down without proof the lens maker's formula for a thin lens in air.

[4 marks]

(b) The particle displacement y of air molecules due to a sound wave is given by $y = 0.008 \cos wt \sin kz$. Where $k = \frac{4\pi}{m}$ and $w = 50\pi\ rad/s$. Calculate:

i. the distance between two consecutive nodes;

ii. the amplitude after 0.565s. **[3 marks]**

(c) A truck travels down a highway at a speed of 66 m/s with its horns emitting sound at a frequency of 800 Hz. What frequency is heard by a passenger in a car travelling at 60 m/s in the same direction, as the car and truck approach each other? (Take the speed of sound in air to be 350 m/s)

[3 marks]

[Total = 10 marks]

PHY 003: ELECTRICITY AND MAGNETISM

5. A circuit used to measure the energy transferred from a battery is as shown in fig. 2a. The energy is transferred to a variable resistor of resistance *R*.

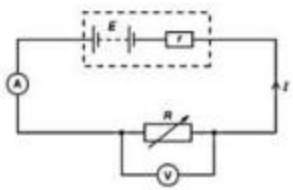


fig. 2a

The battery has an electromotive force (e.m.f.) *E* and an internal resistance *r*. The Potential difference (p.d.), across *R is V*. The current in the circuit is *I*.

(a) i. With reference to the circuit, distinguish between the definitions of e.m.f. and p.d.;

ii. State Kirchhoff's second law;

iii. Using Kirchhoff's second law, determine an expression for the current *I* in the circuit.

[4 marks]

(b) The variation with current *I* of the p.d. *V* across *R* is shown in fig. 2b.

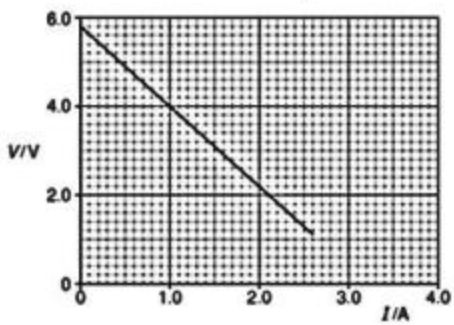


fig. 2b

Use Fig. 2b to determine

i. the e.m.f. E;

ii. the internal resistance r. **[2 marks]**

(c) i. Using data from Figure 2b in (b) above, calculate the energy transferred to R per unit time for a current of 1.6 A.

ii. Use your answers from (b)(i) and (c)(i) to calculate the efficiency of the battery for a current of 1.6 A.

[4 marks]

[Total = 10 marks]

6. (a) i. State Fleming's left hand rule.

ii. State two factors upon which the magnitude of the force on a charge moving in a magnetic field depends on.

[3 marks]

(b) An electron is accelerated by a 5.2 kV potential difference. How strong a magnetic field must be experienced by the electron if its path is a circle of radius 4.0 cm?

[3 marks]

(c) A step-up transformer's primary coil has 400 turns. Its secondary coil has 1200 turns. The primary coil is connected to an AC generator having an e.m.f. of 150 V.

i. Calculate the e.m.f. of the secondary circuit.

ii. Find the current in the primary circuit if the current in the secondary circuit is 5 A.

iii. Determine the power drawn by the primary circuit.

iv. Determine the power supplied by the secondary circuit.

[4 marks]

[Total = 10 marks]

PHY 004: MODERN PHYSICS

7. (a) State two advantages and two disadvantages each of fusion power from the viewpoint of safety, pollution, and resources. **[2 marks]**

(b) The radioactive isotope ^{198}Au has a half-life of 64.8 h. A sample containing this isotope has an initial activity ($t = 0$) of 40.0 mCi. Calculate the number of nuclei that decay in the time interval between $t_1 = 10.0$ h and $t_2 = 12.0$ h.
(1 Ci = 3.7×10^{10} Bq) **[3 marks]**

(c) If the average energy released in a fission is 208 MeV, calculate the total number of fission events required to operate a 100 W light bulb for 1.0 h.

[2½ marks]

(d) Molybdenum has a work function of 4.20 eV. What is the stopping potential if the incident light has a wavelength of 180 nm? **[2½ marks]**

[Total = 10 marks]

8. (a) Define a photon. **[2 marks]**

(b) A photon of wavelength 0.0033 nm is incident on an isolated stationary electron of mass m_e.

The photon is deflected elastically by the electron. The wavelength of the deflected photon is 0.0038 nm. Calculate for the incident photon,

i. its momentum;

ii. its energy. **[5 marks]**

(c) The angle Θ through which the photon is deflected is given by the expression

$$\Delta\lambda = \frac{h}{m_e c}(1 - \cos\Theta)$$

i. State the phenomena represented by the above expression and hence identify the symbols used in the expression.

ii. Calculate the angle Θ using the information given in question 8b above.

[3 marks]

[Total = 10 marks]