The University of Nottingham Ningbo China

Centre for English Language Education

AUTUMN SEMESTER SAMPLE EXAM 2017-2018

SCIENCE A – Physics

Time allowed: **TWO HOURS**

Candidates may complete the front cover of the answer book and sign the attendance card.

Candidates must NOT start writing their answers until told to do so.

There are 6 questions. ATTEMPT ANY 4 QUESTIONS. Each question is worth 25 marks.

Only silent, self-contained calculators with a Single-Line Display or Dual-Line Display are permitted in this examination.

Dictionaries are not allowed with one exception: those whose first language is not English may use a standard translation dictionary to translate between that language and English provided that neither language is the subject of this examination.
Subject-specific translation dictionaries are not permitted.

No electronic devices capable of storing and retrieving text, including electronic dictionaries and mobile phones, may be used.

DO NOT turn the examination paper over until instructed to do so.

INFORMATION FOR INVIGILATORS:
Please collect the examination paper and the answer booklets at the end of the exam.
A 15-minute warning should be announced before the end of the exam.

Constants:

$$k = 8.99 \times 10^{9}\mathrm{N} \cdot \mathrm{m}^2/\mathrm{C}^2$$
$$\varepsilon_0 = 8.85 \times 10^{-12}\mathrm{C}^2/\mathrm{N} \cdot \mathrm{m}^2$$
$$\mathrm{g} = 9.80\ \mathrm{m}/s^2$$
$$\mu_0 = 4\pi \times 10^{-7}\mathrm{T} \cdot \mathrm{m}/\mathrm{A}$$

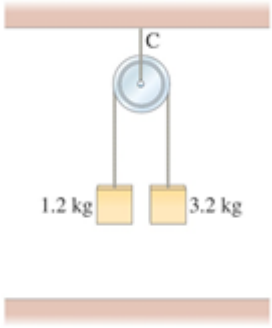
Q.1 (25 Marks)

Answer each of the following questions.

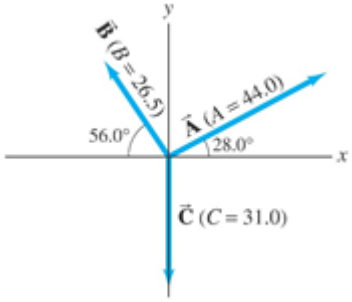
A. A stone is thrown vertically upward with a speed of 24.0 m/s.
(i) How fast is it moving when it reaches a height of 13.0 m?
(ii) How much time is required to reach this height?
(iii) Why are there two answers to (ii)?

B. Suppose you adjust your garden hose nozzle for a hard stream of water. You point the nozzle vertically upward at a height of 1.5 m above the ground (shown in the figure below). When you quickly turn off the nozzle, you hear the water striking the ground next to you for another 2.0 s. What is the water speed as it leaves the nozzle?

C. Suppose the pulley in the figure below is suspended by a cord C. Determine the tension in this cord after the masses are released and before one hits the ground. Ignore the mass of pulley and cords.



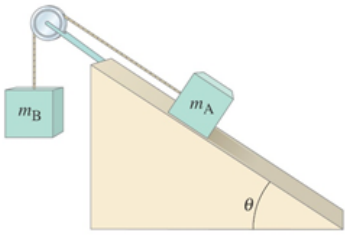
D. Three vectors are shown in the figure below. Their magnitudes are given in arbitrary units. Determine the sum of the three vectors. Give the resultant in terms of
(i) components, and
(ii) magnitude and angle with the *x* axis.



Q.2 (25 Marks)

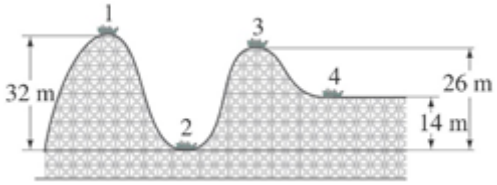
Answer each of the following questions.

A. Suppose the coefficient of kinetic friction between m_A and the plane in the figure below is $\mu_k = 0.15$, and that $m_A = m_B = 2.7$ kg. As m_B moves down, determine
(i) the magnitude of the acceleration of m_A and m_B, given $\theta = 34°$.
(ii) What smallest value of μ_k will keep the system from accelerating?

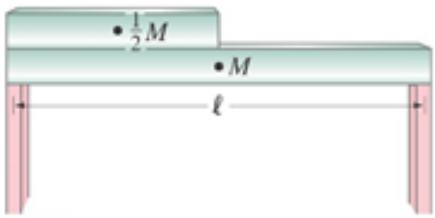


B. A 46.0 kg crate, starting from rest, is pulled across a floor with a constant horizontal force of 225 N. For the first 11.0 m the floor is frictionless, and for the next 10.0 m the coefficient of friction is 0.20. What is the final speed of the crate after being pulled these 21.0 m?

C. A roller-coaster car shown in the figure below is pulled up to point 1 where it is released from rest. Assuming no friction, calculate the speed at points 2, 3 and 4.



D. A uniform steel beam has a mass of 940 kg. On it is resting half of an identical beam, as shown in the figure below. What is the vertical support force at each end?



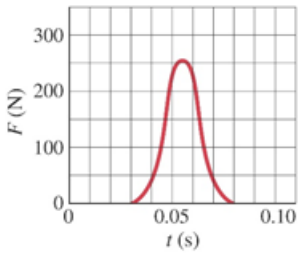
Q.3 (25 Marks)

Answer each of the following questions.

A. Suppose the force acting on a tennis ball (mass 0.060 kg) points in the +*x* direction and is given by the graph shown in the figure below as a function of time.Use graphical methods to estimate

(i) the total impulse given the ball, and

(ii) the velocity of the ball after being struck, assuming the ball is being served so it is nearly at rest initially.



B. A 0.35 kg mass at the end of a spring oscillates 2.5 times per second with an amplitude of 0.15 m. Determine

(i) the velocity when it passes the equilibrium point,

(ii) the velocity when it is 0.10 m from equilibrium,

(iii) the total energy of the system, and

(iv) the equation describing the motion of the mass, assuming that at $t = 0$, x was a maximum.

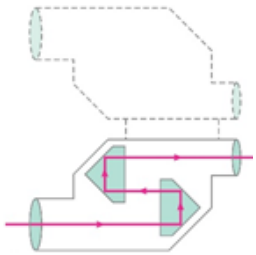
C. A fire hose exerts a force on the person holding it. This is because the water accelerates as it goes from the hose through the nozzle. How much force is required to hold a 7.0 cm diameter hose delivering 450 L/min through a 0.75 cm diameter nozzle?

D. Given the binoculars shown in the figure below,

(i) What is the minimum index of refraction for a glass or plastic prism to be used so that total internal reflection occurs at 45°?

(ii) Will binoculars work if their prisms (assume $n = 1.58$) are immersed in water?

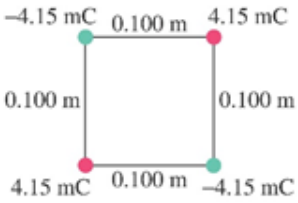
(iii) What minimum n is needed if the prisms are immersed in water?



Q.4 (25 Marks)

Answer each of the following questions.

A. Two negative and two positive point charges (magnitude Q = 415 mC) are placed on opposite corners of a square as shown in the figure below. Determine the magnitude and direction of the force on each charge.



B. The electric field between two square metal plates is 160 N/C. The plates are 1.0 m on a side and are separated by 3.0 cm, as shown in the figure below. What is the charge on each plate? Neglect edge effects.

C. A 32 cm diameter conducting sphere is charged to 680 V relative to $V = 0$ at $r = \infty$.

(i) What is the surface charge density σ?

(ii) At what distance will the potential due to the sphere be only 25 V?

D. The work done by an external force to move a -9.10 μC charge from point a to point b is 7.00×10^{-4} J. If the charge was started from rest and had 2.10×10^{-4} J of kinetic energy when it reached point b, what must be the potential difference between a and b?

E. A parallel-plate capacitor has fixed charges $+Q$ and $-Q$. The separation of the plates is then tripled.

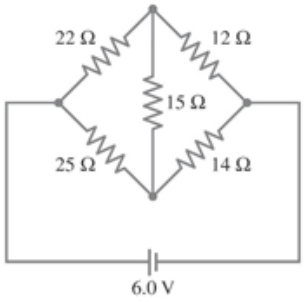
(i) By what factor does the energy stored in the electric field change?

(ii) How much work must be done to increase the separation of the plates from d to $3.0d$? The area of each plate is A.

Q.5 (25 Marks)

Answer each of the following questions.

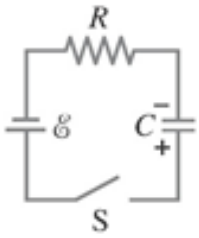
A. Determine the current through each of the resistors in the figure below.



B. In the figure below, the total resistance is 15.0 kΩ, and the battery's emf is 24.0 V. If the time constant is measured to be 24.0 μs, calculate

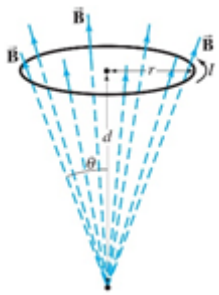
(i) the total capacitance of the circuit and

(ii) the time it takes for the voltage across the resistor to reach 16.0 V after the switch is closed.



C. An electron is projected vertically upward with a speed of 1.70×10^{6} m/s into a uniform magnetic field of 0.480 T that is directed horizontally away from the observer. What is the radius of motion? The mass of an electron is 9.11×10^{-31}kg, and the charge on an electron is 1.66×10^{-19} C.

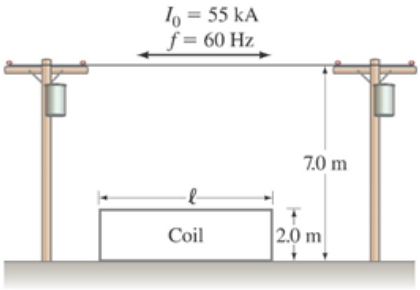
D. A circular loop of wire, of radius *r,* carries current *I*. It is placed in a magnetic field whose straight lines seem to diverge from a point a distance *d* below the loop on its axis. In other words, the field makes an angle θ with the loop at all points, as shown in the figure below, where $\tan\theta = r/d$. Determine the force on the loop.



Q.6 (25 Marks)

Answer each of the following questions.

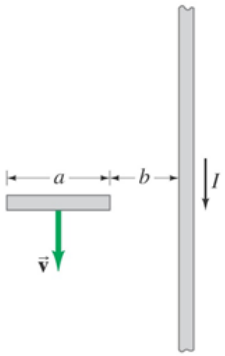
A. A power line carrying a sinusoidally varying current with frequency f = 60 Hz and peak value $/_0$ = 55 kA runs at a height of 7.0 m across a farmer's land (as shown in the figure below). The farmer constructs a vertically oriented 2.0 m high 10 turn rectangular wire coil below the power line. The farmer hopes to use the induced voltage in this coil to power 120 volt electrical equipment, which requires a sinusoidally varying voltage with frequency f = 60 Hz and peak value V_0 = 170 V. What should the length l of the coil be?



B. A short section of wire, of length *a,* is moving with velocity **v,** parallel to a very long wire carrying a current *I* as shown in the figure below. The near end of the wire section is a distance *b* from the long wire. Assuming the vertical wire is very long compared to *a* + *b,* determine the emf between the ends of the short section. Do this for when **v** is

(i) in the same direction as *I,* and

(ii) in the opposite direction to *I*.



C. A 250 loop circular armature coil with a diameter of 10.0 cm rotates at 120 rev/s in a uniform magnetic field of strength 0.45 T. What is the rms voltage output of the generator? What would you do to the rotation frequency in order to double the rms voltage output?

D. A motor has an armature resistance of 3.05 Ω. If it draws 7.20 A when running at full speed and connected to a 120-V line, how large is the back emf?

E. A 75 W lightbulb is designed to operate with an applied ac voltage of 120 V rms. The bulb is placed in series with an inductor *L,* and this series combination is then connected to a 60 Hz 240 V rms voltage source. For the bulb to operate properly, determine the required value for *L*. Assume the bulb has resistance *R* and negligible inductance.