The University of Nottingham Ningbo China

Centre for English Language Education

AUTUMN SEMESTER 2017-2018 ANSWERS

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?

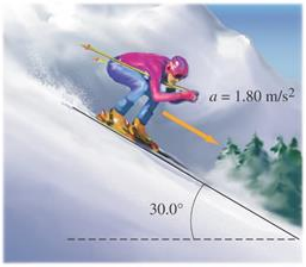
(ii) How much time is required to reach this height?

(iii) Why are there two answers to (ii)?

B. A skier is accelerating down a 30.0° hill at 1.80 m/s^2, as shown in the figure below.

(i) What is the vertical component of her acceleration?

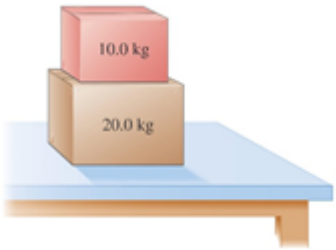
(ii) How long will it take her to reach the bottom of the hill, assuming she starts from rest and accelerates uniformly, if the elevation change is 325 m?



C. A 20.0 kg box rests on a table,as shown in the figure below.

(i) What is the weight of the box and the normal force acting on it?

(ii) A 10.0 kg box is placed on top of the 20.0 kg box, also shown in the figure below. Determine the normal force that the table exerts on the 20.0 kg box and the normal force that the 20.0 kg box exerts on the 10.0 kg box.



D. The position of a small object is given by the equation $x = 5 + 5t$, where t is in seconds and x is in metres.

(i) Plot x as a function of t from $t = 0$ to $t = 3.0$ s.

(ii) What does the value for the slope of the line for $x = 5 + 5t$ mean?

(iii) If the slope of the line in part (ii) is doubled, what will be the equation that now describes the position of the small object?

(iv) Evaluate the integral of the equation $x = 5 + 5t$ between $t = 0$ to $t = 3.0$ s? What does the integral mean in this context? Use appropriate graphs to explain your reasoning.

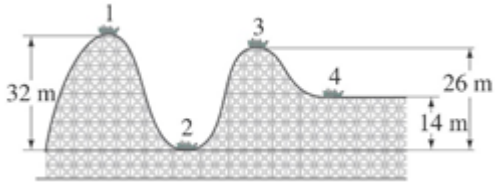
Q.2 (25 Marks)

Answer each of the following questions.

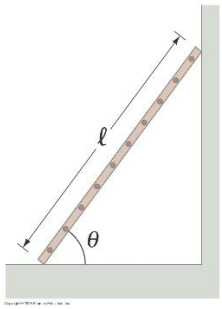
A. Two masses m_A = 2.0 kg and m_B = 5.0 kg are on inclines and are connected together by a string as shown in the figure below. The coefficient of kinetic friction between each mass and its incline is μ_k = 0.30. If m_A moves up, and m_B moves down, determine their acceleration.

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. Suppose the roller-coaster shown in the figure below passes point 1 with a speed of 1.70 m/s. If the average force of friction is equal to 0.23 of its weight, with what speed will it reach point 2? The distance traveled is 45.0 m.



D. A uniform ladder of mass *m* and length l leans at an angle θ against a frictionless wall, as shown in the figure below. If the coefficient of static friction between the ladder and the ground is μ_s, determine a formula for the minimum angle at which the ladder will not slip.



Q.3 (25 Marks)

Answer each of the following questions.

A. A 130 kg astronaut (including space suit) acquires a speed of 2.50 m/s by pushing off with his legs from a 1700 kg space capsule.

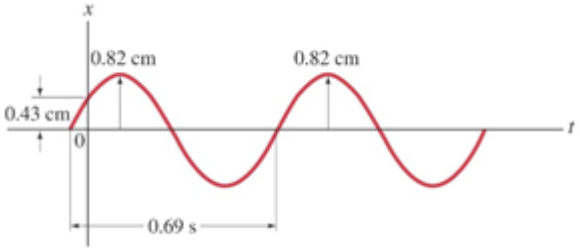
(i) What is the change in speed of the space capsule?

(ii) If the push lasts 0.500 s, what is the average force exerted by each on the other? As the reference frame, use the position of the capsule before the push.

B. The graph of displacement vs. time for a small mass *m* at the end of a spring is shown in the figure below. At $t = 0$, $x = 0.43$ cm.

(i) If $m = 9.5$ g, find the spring constant, *k.*

(ii) Write the equation for displacement *x* as a function of time.



C. An object with mass 2.7 kg is executing simple harmonic motion, attached to a spring with spring constant $k = 280$ N/m. When the object is 0.020 m from its equilibrium position, it is moving with a speed of 0.55 m/s.

(i) Calculate the amplitude of the motion.

(ii) Calculate the maximum speed attained by the object.

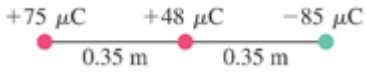
D. A fire hose exerts a force on the person holding it. This is because the water accelerates as it goes from the hose through the nozzle. How much force is required to hold a 7.0 cm diameter hose delivering 450 L/min through a 0.75 cm diameter nozzle?

E. A ray of light, after entering a light fibre, reflects at an angle of 14.5° with the long axis of the fibre, as shown in the figure below. Calculate the distance along the axis of the fibre that the light ray travels between successive reflections off the sides of the fibre. Assume that the fibre has an index of refraction of 1.55 and is 1.40×10^{-4} m in diameter.

Q.4 (25 Marks)

Answer each of the following questions.

A. Particles of charge +75, +48, and -85 µC are placed in a line as shown in the figure below. The centre one is 0.35 m from each of the others. Calculate the net force on each charge due to the other two.



B. A flat square sheet of thin aluminum foil, 25 cm on a side, carries a uniformly distributed 275 ηC charge. What, approximately, is the electric field
(i) 1.0 cm above the centre of the sheet and
(ii) 15 m above the centre of the sheet?

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. An electric field of 4.80×10^5 V/m is desired between two parallel plates, each of area 21.0 cm^2 and separated by 0.250 cm of air. What charge must be on each plate?

E. How much energy must a 28 V battery expend to charge a 0.45 µF and a 0.20 µF capacitor fully when they are placed
(i) in parallel; and
(ii) in series?
(iii) How much charge flows from the battery in each case?

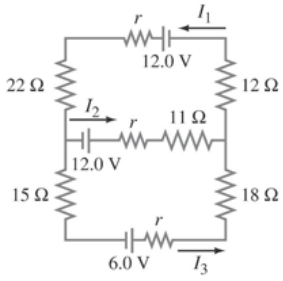
Q.5 (25 Marks)

Answer each of the following questions.

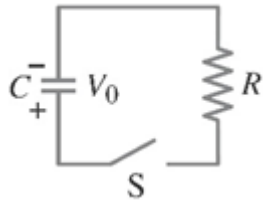
A. The figure below is considered a complex circuit.

(i) Determine the currents I_1, I_2, and I_3. You can assume that the internal resistance of each battery is $r = 1.0\ \Omega$.

(ii) What is the terminal voltage of the 6.0 V battery?

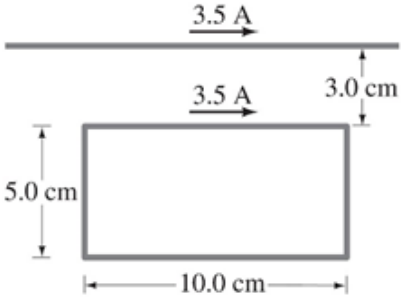


B. The *RC* circuit in the figure below has $R = 8.7\ \text{k}\Omega$ and $C = 3.0\ \mu\text{F}$. The capacitor is at voltage V_0 at $t = 0$, when the switch is closed. How long does it take the capacitor to discharge to 0.10% of its initial voltage?



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 rectangular loop of wire is placed next to a straight wire, as shown in the figure below. There is a current of 3.5 A in both wires. Determine the magnitude and direction of the net force on the loop.



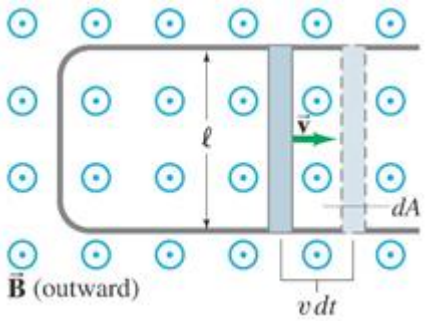
Q.6 (25 Marks)

Answer each of the following questions.

A. A 420 turn solenoid, 25 cm long, has a diameter of 2.5 cm. A 15 turn coil is wound tightly around the centre of the solenoid. If the current in the solenoid increases uniformly from 0 to 5.0 A in 0.60 s, what will be the induced emf in the short coil during this time? The value for the permeability of free space (μ_0) is $4\pi \times 10^{-7}\mathrm{T} \cdot \mathrm{m/A}$.

B. In the figure below, the rod moves to the right with a speed of 1.3 m/s and has a resistance of 2.5 Ω. The rail separation is l = 25.0 cm. The magnetic field is 0.35 T, and the resistance of the U-shaped conductor is 25.0 Ω at a given instant. Calculate

(i) the induced emf
(ii) the current in the U-shaped conductor, and
(iii) the external force needed to keep the rod's velocity constant at that instant.



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?

C. The back emf in a motor is 85 V when the motor is operating at 1100 rpm. How would you change the motor's magnetic field if you wanted to reduce the back emf to 75 V when the motor was running at 2300 rpm?

D.

E. A 35 mH inductor with 2.0 kΩ resistance is connected in series to a 26-μF capacitor and a 60-Hz, 45-V (rms) source. Calculate

(i) the rms current,
(ii) the phase angle, and
(iii) the power dissipated in this circuit.