

Cork Institute of Technology
Higher Certificate in Science in Applied Biology - Stage 1
(National Certificate in Science in Applied Biology - Stage 1)
(NFQ – Level 6)
Autumn 2005
PHYSICS
(Time: 3 Hours)

Answer **FIVE** questions only.

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SHOW ALL WORKING.

$$\begin{aligned} k &= 1.38 \times 10^{-23} \text{ JK}^{-1}; & h &= 6.6 \times 10^{-34} \text{ J s}; \\ e &= 1.6 \times 10^{-19} \text{ C}; & c &= 3 \times 10^8 \text{ ms}^{-1}; \\ g &= 9.81 \text{ ms}^{-2}. \end{aligned}$$

- Q1 (a) An ant moving around a paving stone to collect food moves 0.15 m due North, 0.50 m due East, 0.15 m due South and finally 0.25 m due East. It takes 150 seconds for the ant to perform these movements. Calculate:
- (i) the *displacement* and the *distance travelled*;
 - (ii) the *velocity* of the ant. [6 marks]
- (b) A cyclist of mass 90 kg, suddenly accelerates horizontally from 5.0 ms^{-1} to 8.0 ms^{-1} over a time of 0.75 s to take the lead in a race. At a later point in the race the cyclist climbs a hill.
- (i) Calculate the *acceleration* of the cyclist when taking the lead on the horizontal.
 - (ii) How much does the cyclist *weigh on Earth*? How much would he weigh in *space*?
 - (ii) The cyclist travelling with a velocity of 5.0 ms^{-1} . Convert this velocity to *kilometers per hour*
 - (iv) Name TWO possible *energy conversions* taking place when the cyclist climbs the hill. [14 marks]

Q2 (a) An object of height 5.0 cm is placed 9.0 cm in front of a biconvex converging lens of focal length 6.0 cm.

(i) Calculate the *position* and *height* of the image.

(ii) State (with reasons) the orientation (*erect/virtual*) and nature (*real/virtual*).

(iii) Sketch a labelled ray diagram to show how the lens produces an image of the object.

Indicate the *principal axis*, *lens*, *object* and *image*. [13 marks]

(b) Cork 96FM broadcasts at a frequency of 96.5 MHz. The radio waves travel with the velocity of light.

(i) Calculate the *wavelength* of the *radio waves*.

(ii) Name TWO other types of *electromagnetic waves* other than radio waves. [7 marks]

Q3. (a) A cast iron fire grate has a width of 35 cm at 20 °C. How much will it expand when the fire reaches a temperature of 820 °C.

(The coefficient of linear expansion of iron is $1.2 \times 10^{-5} \text{ }^{\circ}\text{C}^{-1}$). [6 marks]

(b) State THREE methods of *heat transfer*. Briefly state how the heat is transferred from one location to another in each case. [6 marks]

(c) A freezer, which is to be defrosted contains 4.0 kg of ice at a temperature of -6°C.

How much heat energy is required to melt the ice.

(The specific heat capacity of ice is $2100 \text{ J kg}^{-1} \text{ K}^{-1}$; the specific latent heat of fusion of ice is 333 kJ K^{-1}). [8 marks]

Q4. (a) How many electrons, protons and neutrons are in the neutral atom $^{40}_{18}\text{Ar}$? [3 marks]

(b) Define an *isotope*. [3 marks]

(c) The decay constant of a nucleus is 75 s^{-1} . Initially there are 3.0×10^{24} radioactive nuclei.

Calculate:

(i) the *half-life* [$\tau_{1/2}$] of the material [5 marks]

(ii) the *initial activity* [dN/dt] of the material [5 marks]

(d) A photon emitted by a sodium discharge lamp has a frequency of $5.09 \times 10^{14} \text{ Hz}$. Calculate the *energy* of the photon. [4 marks]

Q5. (a) State the *Law of Conservation of Linear Momentum*. [3 marks]

(b) In a crash test research centre, a car of mass 550 kg travelling at 30 ms^{-1} , collides head on with a van of mass 700 kg travelling at 25 ms^{-1} . The two are crushed together and joined after the collision.

(i) What is the *final speed* and *direction* of the combined vehicles? [8 marks]

(ii) What is the *difference* between total initial kinetic energy and the final kinetic energy? [6 marks]

(iii) Explain this difference. [1 mark]

(iv) Is this an *elastic* or *inelastic* collision? Give a reason for your answer. [2 marks]

Q6. (a) Explain the concept of *capillarity* and give one common example of it. [4 marks]

(b) Find the *pressure* on a diver at a depth of 40 m who is diving in seawater of density 1025 kg m^{-3} . [3 marks]

(c) Find the *pressure increase* in the fluid inside a syringe when a nurse applies a force of 45.6 N to the syringe's piston of diameter 1.15 cm. [6 marks]

(d) Suppose that blood flows through an aorta with a speed of 0.35 ms^{-1} . The radius of the aorta is 10 mm. The aorta branches into tens of thousands of capillaries whose total cross-sectional area is $2.8 \times 10^{-2} \text{ m}^2$. Calculate:

(i) The *volume flow rate* of the blood.

(ii) State the *Equation of Continuity* for flow.

(iii) The *flow velocity* in the capillaries. [7 marks]

Q7. (a) A block of crown glass is placed on top of a printed page. The block is 6cm thick. When viewed directly from above, how *far above* the page does the printing appear to be?

Refractive index of crown glass, $n_g = 1.52$. [4 marks]

(b) Answer part (i) or part (ii):

(i) *Either* describe what is meant by the polarisation of light waves;

(ii) *Or* explain what are the properties and differences of *longitudinal waves* and *transverse waves*. [4 marks]

(c) Sketch a diagram of an *optical spectrometer*. Label the important parts of the spectrometer and explain their function. [4 marks]

(d) A spectral line of known wavelength, 5.792×10^{-7} m, emitted from a mercury vapour lamp is used to determine the spacing, d , between lines ruled on a plane diffraction grating. When light is incident normally on the grating, the *third order spectrum*, measured using a spectrometer, occurs at an angle of 60.32° . Calculate the *grating spacing*, d . [8 marks]