

# Cork Institute of Technology

## Bachelor of Science in Applied BioSciences – Stage 1(Old Syllabus)

(NFQ Level 7)

Summer 2008

### Physics

(Time: 3 Hours)

Answer **FIVE** questions only.

Examiners: Dr. M. E. Woods  
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**SHOW ALL WORKING.**

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

Q1. (a) Sketch diagrams to show how light waves from two coherent sources with the same amplitude can combine to give: (i) *constructive interference*, (ii) *destructive interference*.

Label the *amplitude* and *wavelength* of the waves on one of the diagrams. (6 marks)

(b) Sketch a diagram of an *optical spectrometer*. Label the important parts of the spectrometer and explain their function. Show the optical spectrometer set-up to measure the wavelengths of emission lines from a light source using a suitable optical device.

(6 marks)

(c) The wavelength of a red line from a light source is measured to be 630 nm on a spectrometer using a diffraction grating. The grating has 500-lines per mm. What is the *angle of diffraction* [ $\theta$ ] of the first order line? Why would the angle be much smaller if Young's slits were used instead of a diffraction grating? (8 marks)

- Q2. (a) A swimmer dives to the bottom of a swimming pool 2.5 m deep, filled with water of density  $1000 \text{ kg m}^{-3}$ . What water pressure is exerted on the swimmer? (4 marks)
- (b)  $2 \text{ cm}^3$  of vaccine is injected in a time of 5.0 s into a patient. The needle of the syringe has a bore of radius 0.30 mm. Determine:
- The *volume flow rate* through the syringe;
  - The *area* of the bore of the needle;
  - The *velocity* of flow through the needle. (11 marks)
- (c) Explain why water rises up a thin glass tube. Name the effect and fully describe the *forces* involved. State ONE *application* of this effect. (5 marks)
- Q3. (a) 0.5 kg of water is placed in a kettle and heated from  $20^\circ\text{C}$  to its boiling point at  $100^\circ\text{C}$ . How *much heat energy* will be required to get the water to boil? If the heating element is rated at 1.5 kW, *how long* will it take for the kettle to boil? [Assume no heat losses from the kettle. The specific heat capacity of water is  $4200 \text{ J kg}^{-1} \text{ K}^{-1}$ .] (9 marks)
- (b) How much will a steel bridge of length 300 m expand if the temperature changes from  $10^\circ\text{C}$  to  $30^\circ\text{C}$ ? [The linear coefficient of expansion of steel is  $1.2 \times 10^{-5} \text{ K}^{-1}$ ] (5 marks)
- (c) State THREE methods of *heat transfer*. Briefly state how the heat is transferred from one location to another in each case. (6 marks)
- Q4. A jet car of mass 2000 kg is undergoing a trial run to break a speed record. The driver wants the car to reach a final velocity of  $240 \text{ ms}^{-1}$ . The car accelerates at  $30 \text{ ms}^{-2}$  when the jet engine is running. The speedometer on the car is in kilometres per hour.
- What is the required *final velocity in kilometres per hour*? (4 marks)
  - How long* does it take the car to reach a velocity of  $240 \text{ ms}^{-1}$  from a standing start? (5 marks)
  - What is the value of the *net force* on the car when it is accelerating? (5 marks)
  - What is the *gain in kinetic energy* of the car when it accelerates from  $120 \text{ ms}^{-1}$  to  $200 \text{ ms}^{-1}$ ? (6 marks)

- Q5. (a) An object is embedded an apparent depth of 0.8 cm in a block of ice of refractive index 1.31. Determine:
- the *velocity of light* in the ice [ $v$ ];
  - the *real depth* of the embedded object in the ice. (6 marks)
- (b) A beam of light propagates through diamond ( $n_1 = 2.42$ ) and strikes a diamond-air interface at an angle of incidence of  $28^\circ$ . Determine the critical angle for total internal reflection to occur. Hence state if part of the beam will enter the air ( $n_2 = 1.00$ ). (6 marks)
- (c) An object is placed 7 cm to the left of a diverging lens whose focal length is 5 cm. Find the image distance, determine whether the image is real or virtual and obtain the magnification of the image. (8 marks)
- Q6. (a) State the *law of conservation of momentum*. (2 marks)
- (b) Two bumper cars collide as one approaches the other directly from behind. One has a mass of 400 kg and the other 430 kg due to the differences in passenger mass. If the lighter one has an initial velocity of  $5.0 \text{ ms}^{-1}$  and the other is moving at  $4.5 \text{ ms}^{-1}$  calculate their common velocity after the collision. Assume that the cars lock together after the collision. (8 marks)
- (c) State the *law of conservation of energy*. (2 marks)
- (d) A 70 kg jogger runs up a flight of stairs of vertical height 4.5 m. Estimate:
- The weight of the jogger.
  - The potential energy of the jogger at the top of the stairs. (8 marks)

- Q7. (a) Calculate the *equivalent resistance* [ $R_{eq}$ ] when resistors  $R_1 = 5 \, \Omega$ ,  $R_2 = 10 \, \Omega$ ,  $R_3 = 15 \, \Omega$  are connected in parallel. (4 marks)
- (b) The emf of a battery is 12.0 V. When a  $20.0 \, \Omega$  resistor is connected across the terminals of the battery, the voltage across the resistor and terminals is measured to be  $V = 5.0 \, \text{V}$ . Determine the *current* [ $I$ ] in the circuit and the *internal resistance* [ $r$ ] of the battery. (6 marks)
- (c) Ultraviolet light is responsible for sun tanning. Calculate the frequency and the wavelength (in nm) of an ultraviolet photon whose energy is  $6.4 \times 10^{-19} \, \text{J}$ . (7 marks)
- (d) Carbon-14 has a decay constant of  $\lambda = 3.83 \times 10^{-12} \text{s}^{-1}$ . Determine the *half-life* [ $T_{1/2}$ ] for carbon-14. (3 marks)