



# Physics

## Sample

### Examination Paper

**Answer ALL questions.**

**Clearly cross out surplus answers.**

**Time: 2 hours**

**The maximum mark for this paper is 100.**

**Any reference material brought into the examination room must be handed to the invigilator before the start of the examination.**

**Candidates are allowed to use a scientific calculator during this examination.**

Note: Scientific calculators permitted in the exam should **not** be able to carry out algebraic manipulation, differentiation or integration, language translation or communication with other devices or the internet. They should **not** have a QWERTY keyboard. There should **not** be any retrievable information stored in the calculator, for example databanks, dictionaries, mathematical formula or text.

**You must show your workings.**  
**Marks are awarded for these.**

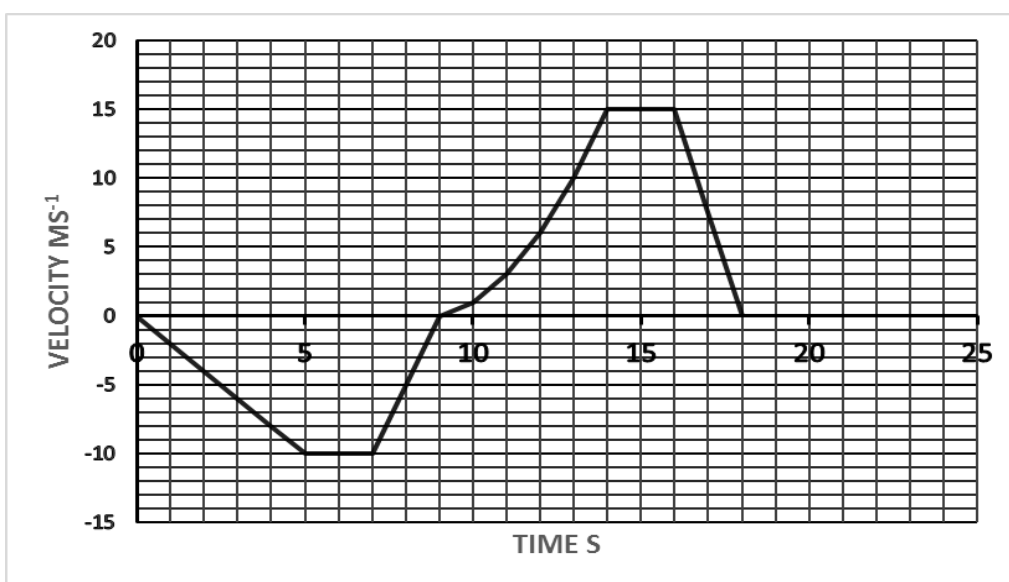
**Please refer to the formula sheet at the end of this examination paper.**

**Answer ALL questions**

**Marks**

**Question 1**

- a) A football is dropped from a helicopter that is flying horizontally with a velocity of  $100\text{ms}^{-1}$  at a height of 250m.
- i) What horizontal distance does the football cover before hitting the ground? **2**
  - ii) A girl kicks the football along the ground at a wall 1.5m away. The ball strikes the wall normally and rebounds in the opposite direction, the girl, who has not moved, stops the ball a short time later. **2**  
Explain why the final displacement of the ball is not 3m.
- b) State the difference between a vector and scalar quantity. **1**
- c) Give an example of a vector quantity (other than force) and one example of a scalar quantity. **2**
- d) A cyclist accelerates uniformly from rest to a speed of  $8\text{ms}^{-1}$  in 25s then brakes at uniform deceleration to a halt in a distance of 22m.
- i) For the first part of the journey, calculate the acceleration. **2**
  - ii) For the first part of the journey calculate the distance travelled **2**
  - iii) For the second part of the journey, calculate the deceleration. **2**
- e) If an object moves in a circle, then what is the name of the force which is stopping the object flying off in a straight line? **1**
- f) The graph below shows how the velocity of a toy car moving in a straight line varies over time. **6**

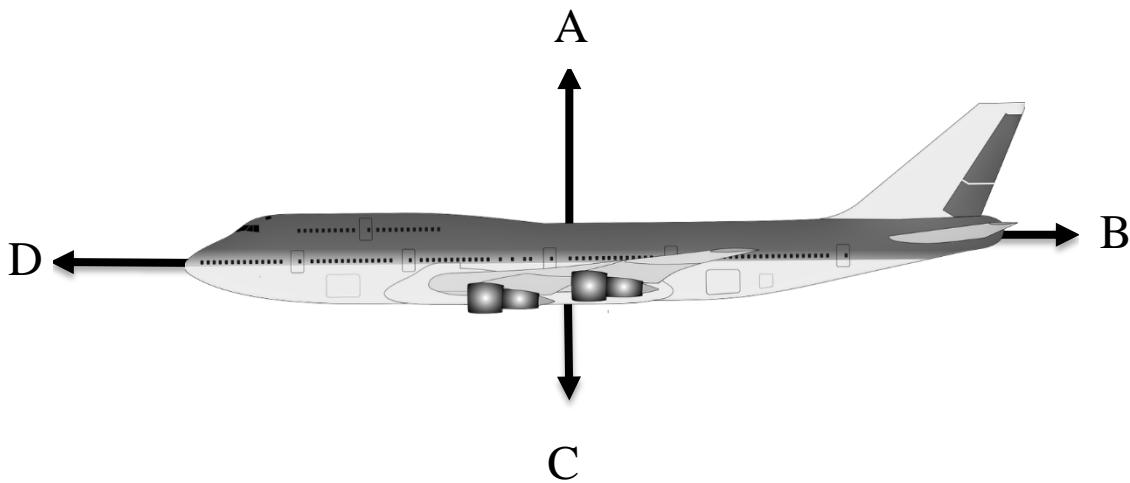


- i) Describe the motion of the car in the following regions of the graph.  
 AB    BC    CD    DE    EF    FG

**Total 20 Marks**

Question 2

- a) The diagram shows an aeroplane travelling at a constant velocity following a horizontal trajectory.



- |              |  |   |
|--------------|--|---|
| i)           | Name the forces A,B,C and D acting on the aeroplane.   | 2 |
| ii)          | By using Newton's Laws of motion, explain why the aeroplane is travelling at constant velocity.  | 2 |
| iii)         | After five minutes the forces change on the aeroplane. This results in a forward acceleration of $75\text{ms}^{-2}$ . If the mass of the aeroplane is 52 000 Kg then calculate the magnitude of the new resultant force. | 2 |
| iv)          | Calculate the work done by the jet engines if the aeroplane travels 5.5km during this period of acceleration.  | 2 |
| <b>b)</b> i) | State the law of conservation of momentum.   | 1 |
| ii)          | What quantity is not conserved in an inelastic collision?  | 1 |
| iii)         | A gun has a mass of 2.0kg and a recoil velocity of $9\text{ms}^{-1}$ . What is the velocity of the bullet if it has a mass of 0.02kg?  | 3 |
| iv)          | Determine the rotational kinetic energy of an electric motor if its angular velocity is $100\pi\text{ rads}^{-1}$ and its moment of inertia is $50\text{ kgm}^2$ .   | 2 |
| <b>c)</b>    | A ball has a mass 0.20kg and is dropped from an initial height of 1.5m. After impact with the ground, the ball rebounds to a height of 0.85m.  |   |
| i)           | Calculate the speed of the ball immediately before impact.   | 2 |
| ii)          | Calculate the speed of the ball immediately after the impact.  | 2 |
| iii)         | The dissipated energy from the ball ends up where?   | 1 |

**Total 20 Marks**

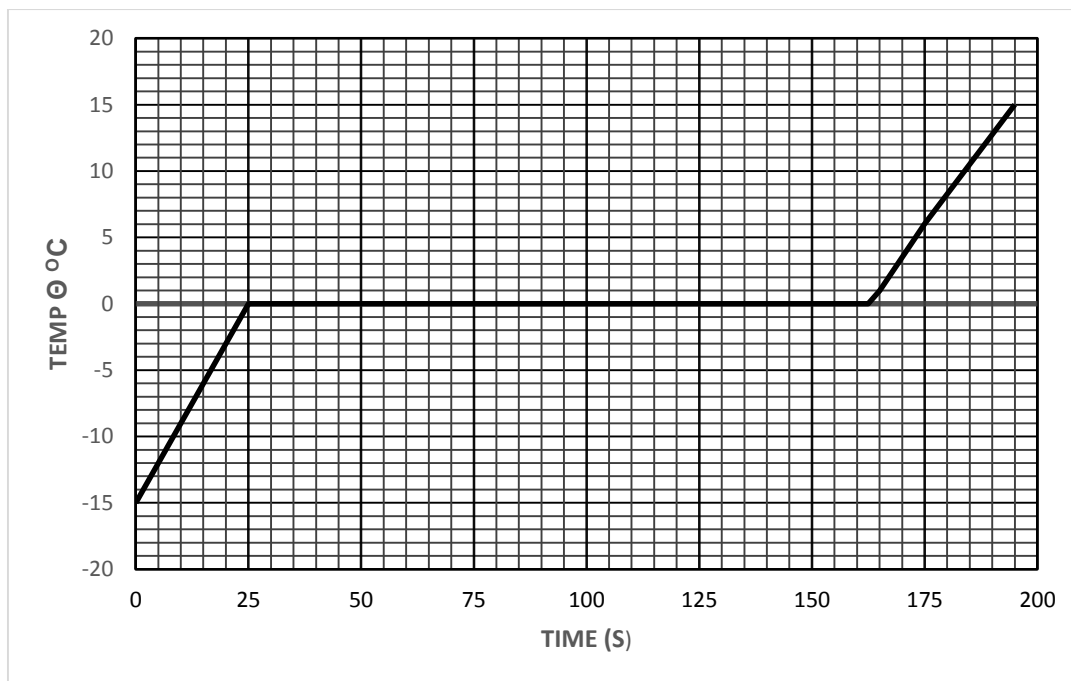
**Question 3****Marks**

- a) A body is in simple harmonic motion of amplitude 0.6m and period  $4\pi$  seconds. What is the speed of the body when the displacement of the body is 0.3m? **2**
- b) A particle of mass  $6.0 \times 10^{-3}$  kg, moving with simple harmonic motion of amplitude 0.15m, takes 52s to make 50 oscillations. What is the maximum kinetic energy of the particle? **2**
- c) Define Thermal energy. **1**
- d) A metal rod has a length of 100cm at  $200^{\circ}\text{C}$ . At what temperature will its length be 99.4cm if the linear expansivity of the material of the rod is  $0.00002/\text{K}$ ? **3**
- e)
- i) Calculate the efficiency of a reversible heat engine operating between a hot reservoir at 900K and a cold reservoir at 500K. **2**
  - ii) The temperature of one of the heat reservoirs can be changed by 100 degrees kelvin up or down. What is the highest efficiency that can be achieved by making this temperature change? **2**
  - iii) Explain thermal equilibrium by reference to the behaviour of the molecules when a sample of hot gas is mixed with a sample of cooler gas and thermal equilibrium is reached. **2**

**Questions Continue on the Next Page**

- f) A quantity of crushed ice is removed from a freezer and placed in a calorimeter. Thermal energy is supplied to the ice at a constant rate. To ensure that all the ice is at the same temperature, it is continually stirred. The temperature of the contents of the calorimeter is recorded every 15 seconds.

The graph below shows the variation with time  $t$  of the temperature  $\theta$  of the contents of the calorimeter.

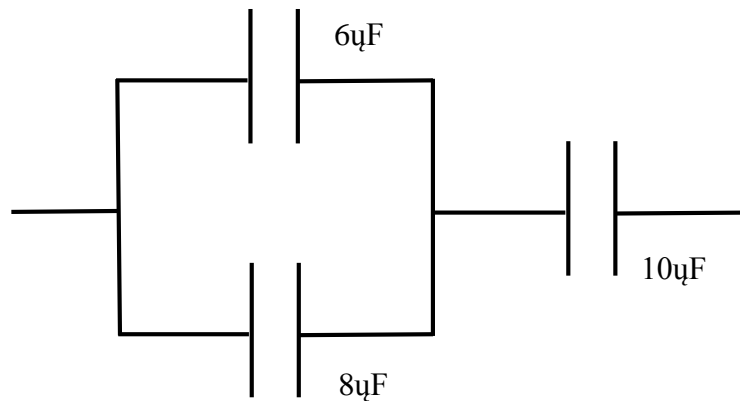


- i) From the graph above, state the coordinates of the data point at which all the ice has just melted. 1
- ii) Explain, with reference to the energy of the molecules, the constant temperature region of the graph. 3
- iii) The mass of ice is 0.25kg and the specific heat capacity of water is  $4200\text{Jkg}^{-1}\text{K}^{-1}$ . 2  
 Use this data and data from the graph to deduce that the energy is supplied to the ice at a rate of approximately 485W.

**Total 20 Marks**

**Question 4****Marks**

- a) The distance between an electron and a point positive charge P of 5 $\mu$ C is 40mm. Given that the charge on an electron is  $1.6 \times 10^{-19}$  C, calculate the magnitude of the force on the positive charge due to the electron. (permittivity of free space  $\epsilon_0 = 8.85 \times 10^{-12} \text{ Fm}^{-1}$ ) **2**
- b) At a point where the distance r from a point charge is 60mm, an electric field has a strength of  $2.5 \times 10^4 \text{ Vm}^{-1}$ . Calculate the potential at this point. **2**
- c) Define the capacitance of a capacitor. **2**
- d) In the diagram below three capacitors have been connected together. Find the equivalent capacitance of the combination of capacitors shown. **3**



- e) A set of decorative lights consists of a string of lamps. Each lamp is rated at 10V, 0.7W and is connected in series to a 230V supply. Calculate
- i) the number of lamps in the set, so that each lamp operates at the correct rating **1**
  - ii) the current in the circuit **1**
  - iii) the resistance of each lamp **1**
  - iv) the total energy transferred by the set of lights in 4 hours. **2**
- f) A lamp is rated at 12V, 9W.
- i) How many joules of energy are transferred by the lamp in 5 minutes? **2**
  - ii) Calculate the current passing through the lamp when it is connected to the 12V supply. **2**
  - iii) Calculate the resistance of the lamp in these circumstances when it is connected to the 12V supply. **2**

**Total 20 Marks**

## Question 5

- a) Explain why a charged particle, moving with a constant speed  $v$  perpendicular to a uniform magnetic field  $B$ , will follow a circular path. **1**
- b) A circular coil of diameter 120 mm has 750 turns. It is placed so that its plane is perpendicular to a horizontal magnetic field of uniform flux density 45 mT.
- i) Calculate the magnetic flux passing through the coil when in this position. **2**
- c) The coil in question (b) is rotated through  $90^\circ$  about a vertical axis in a time of 150ms. Calculate
- i) the change of magnetic flux linkage produced by this rotation. **2**
- ii) the average emf induced in the coil when it is rotated. **2**
- d) A magnetic field is produced around a current carrying wire. What is the strength of the magnetic field at a point P about 3.8 cm from the centre of the wire if the current flowing in the wire is 4.2A? **3**
- e) A piano is being lifted vertically at a constant speed to the top of a build by a cable attached to a crane. The piano has a mass of 750kg.
- i) With reference to one of Newton's laws of motion, explain why the tension  $T$  in the cable must be equal to the weight of the piano. **4**
- f) The piano in question (e) is lifted through a vertical height of 12.0m in 5.5s. Calculate
- i) the work done on the piano. **2**
- ii) the power output of the crane in this situation. **2**
- g) Calculate the height through which a 5kg mass would need to drop to lose the same energy as 100W light bulb would radiate in 1 min. **2**

Total 20 Marks

End of paper

## Formulae and data sheet

## Fundamental constants and values

Quantity	Symbol	Value	Units
Speed of light in a vacuum	$c$	$3.00 \times 10^8$	$\text{ms}^{-1}$
Permeability of free space	$\mu_0$	$4\pi \times 10^{-7}$	$\text{Hm}^{-1}$
Permittivity of free space	$\epsilon_0$	$8.85 \times 10^{-12}$	$\text{Fm}^{-1}$
Magnitude of the charge of electron	$e$	$1.60 \times 10^{-19}$	C
The Planck constant	$h$	$6.63 \times 10^{-34}$	Js
gravitational constant	$G$	$6.67 \times 10^{-11}$	$\text{Nm}^2\text{kg}^{-2}$
Avogadro constant	$N_A$	$6.02 \times 10^{23}$	$\text{Mol}^{-1}$
Molar gas constant	$R$	8.31	$\text{JK}^{-1}\text{mol}^{-1}$
The Boltzmann constant	$k$	$1.38 \times 10^{-23}$	$\text{JK}^{-1}$
The Stefan constant	$\sigma$	$5.67 \times 10^{-8}$	$\text{Wm}^{-2}\text{K}^{-4}$
The Wien constant	$\alpha$	$2.90 \times 10^{-3}$	mK
Electron rest mass	$m_e$	$9.11 \times 10^{-31}$	Kg
Electron charge/mass ratio	$e/m_e$	$1.76 \times 10^{11}$	$\text{Ckg}^{-1}$
Proton rest mass	$m_p$	$1.67(3) \times 10^{-27}$	Kg
Proton charge/mass ratio	$e/m_p$	$9.58 \times 10^7$	$\text{Ckg}^{-1}$
Neutron rest mass	$m_n$	$1.67(5) \times 10^{-27}$	kg
Gravitational field strength	$g$	9.81	$\text{Nkg}^{-1}$
Acceleration due to gravity	$g$	9.81	$\text{ms}^{-2}$
Atomic mass unit	$u$	$1.661 \times 10^{-27}$	kg

## Electricity

Current and pd	$I = \frac{\Delta Q}{\Delta t}$	$V = \frac{W}{Q}$	$R = \frac{V}{I}$
emf	$\epsilon = \frac{E}{Q}$		$\epsilon = I(R + r)$
resistors in series	$R = R_1 + R_2 + R_3 + \dots$		
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$		
resistivity	$\rho = \frac{RA}{L}$		
power	$P = VI = I^2R = \frac{V^2}{R}$		



## Formulae and data sheet – Mechanics

	Moments	$\text{moments} = Fd$
	Velocity and acceleration	$v = \frac{\Delta s}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$
	Equation of motion	$v = u + at$ $s = \frac{(u+v)}{2}t$ $v^2 = u^2 + 2as$ $s = ut + \frac{at^2}{2}$
	Force	$F = ma$
	Work, energy and power	$W = Fscos \theta$ $E_k = \frac{1}{2}mv^2$ $P = \frac{\Delta W}{\Delta t}, P = Fv$ $\Delta E_p = mg\Delta h$ $\text{efficiency} = \frac{\text{useful output power}}{\text{input power}}$
	Momentum	force $F = \frac{\Delta(mv)}{\Delta t}$ Impulse $F\Delta t = \Delta(mv)$
Circular Motion	angular velocity	$\omega = \frac{v}{r}$ $\omega = 2\pi f$
	Centripetal acceleration	$a = \frac{v^2}{r} = \omega^2 r$
	Centripetal force	$F = \frac{mv^2}{r} = m\omega^2 r$
	Moment of inertia	$I = \sum mr^2$
	Angular kinetic energy	$E_k = \frac{1}{2}I\omega^2$
	Equation of angular motion	$\omega_2 = \omega_1 + at$ $\omega_2^2 = \omega_1^2 + 2a\theta$ $\theta = \omega_1 t + \frac{1}{2}at^2$ $\theta = \frac{1}{2}(\omega_1 + \omega_2)t$
	Torque	$T = Ia$
	Angular momentum	angular momentum = $I\omega$
	Work done	$W = T\theta$
	Power	$P = T\omega$

## Formulae and data sheet - Mechanics Continued

Oscillations	acceleration	$a = -(2\pi f)^2 x$
	Displacement	$x = A \cos(2\pi f t)$
	Speed	$v = \pm 2\pi \sqrt{A^2 - x^2}$
	Maximum speed	$v_{max} = 2\pi f A$
	Maximum acceleration	$a_{max} = (2\pi f)^2 A$
	For a mass-spring system	$T = 2\pi \sqrt{\frac{m}{k}}$
	For a simple pendulum	$T = 2\pi \sqrt{\frac{l}{g}}$
Thermodynamics		$Q = \Delta U + W$
		$W = p\Delta V$
	Adiabatic change	$pV^{\gamma} = \text{constant}$
	Isothermal change	$pV = \text{constant}$
Heat engines		efficiency = $\frac{W}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}}$
		maximum efficiency = $\frac{T_H - T_C}{T_H}$
		Work done per cycle = area of loop
		input power = calorific value x fuel flow rate
		Indicated power = (area of $p - V$ loop) x (no. of cycles per second) x number of cylinders
		Output of brake power $P = T\omega$
		Friction power = indicated power – brake power
Heat pumps and refrigerators	Refrigerator	$COP_{ref} = \frac{Q_{out}}{W} = \frac{Q_{out}}{Q_{in} - Q_{out}}$
	Heat pump	$COP_{hp} = \frac{Q_{in}}{W} = \frac{Q_{in}}{Q_{in} - Q_{out}}$

## Formulae and data sheet - Mechanics Continued

Electric Fields and Capacitors	Force between two points charges	$F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2}$
	Force on a charge	$F = EQ$
	Field strength for a uniform field	$E = \frac{V}{d}$
	Field strength for a radical field	$E = \frac{Q}{4\pi\epsilon_0 r^2}$
	Electrical potential	$\Delta W = Q\Delta V$
		$V = \frac{1}{4\pi\epsilon_0} \frac{Q}{r}$
	Capacitance	$C = \frac{Q}{V}$
	Decay of charge	$Q = Q_0 e^{\frac{-t}{RC}}$
	Time constant	$RC$
	Capacitor energy stored	$E = \frac{1}{2} QV = \frac{1}{2} CV^2 = \frac{1}{2} \frac{Q^2}{C}$
Electrons in a field	$F = \frac{eV}{d} \quad F = Bev \quad r = \frac{mv}{Be}$	
	$\frac{1}{2} mv^2 = eV \quad \frac{QV}{d} = mg \quad F = 6\pi\eta rv$	
Magnetic field	Force on a current	$F = BIl$
	Force on a moving charge	$F = BQv$
	Magnetic flux	$\phi = BA$
	Magnetic flux linkage	$N\phi = BAN$
	Magnitude of induced emf	$\epsilon = N \frac{\Delta\phi}{\Delta t}$
	Emf induced in a rotating coil	$N\phi = BAN\cos\theta \quad \epsilon = BAN\omega \sin\omega t$
	Transformer equation	$\frac{N_s}{N_p} = \frac{V_s}{V_p} \quad efficiency = \frac{I_s V_s}{I_p V_p}$
Gas and thermal physics	gas law	$pV = nRT \quad pV = NkT$
	Kinetic theory model	$pV = \frac{1}{3} Nm(c_{rms})^2$
	Kinetic energy of gas molecules	$\frac{1}{2} m(c_{rms})^2 = \frac{3}{2} kT = \frac{3RT}{2N_A}$
	Energy to change temperature	$Q = mc\Delta T$
Energy to change state	$Q = ml$	