Physics Admissions Test

Paper 1 Solutions

OXFORD TUTORS

Assume gravitational field strength $g = 10$ Nkg^{-1} and that resistive forces are negligible unless stated otherwise. Values of fundamental constants will be given in the questions where they are required. Non - graphical calculators are permitted.

Questions: 24 Total Marks : 100

1. For what values of α does the equation $\text{cosec}^2(\theta) + \alpha\cot(\theta) = 0$ have multiple distinct real solutions, for $0 < \theta < \pi$? (2)

A	B	C	D	E
$\alpha < -2$	$\alpha \leq -4$ or $\alpha \geq 4$	$\alpha < -2$ or $\alpha > 2$	$\alpha < -4$ or $\alpha > 4$	$-4 < \alpha < 4$

Solution: C : $\alpha < -2$ or $\alpha > 2$. Simply a quadratic question in disguise, use pythagoras to find a quadratic in $\cot\theta$, and then enforce a positive discriminant for two solutions.

$$\text{cosec}^2(\theta) + \alpha\cot(\theta) = 0$$
$$\cot^2(\theta) + \alpha\cot(\theta) + 1 = 0$$
$$\cot(\theta) = -\frac{\alpha}{2} \pm \frac{\sqrt{\alpha^2 - 4}}{2}$$

2. The Rydberg formula describes the energy levels of the hydrogen atom, where n is the quantum number for each level. (2)

$$E_n = -\frac{13.6\text{eV}}{n^2}$$

The H_α emission line is commonly used in astrophysics to identify regions of active star formation. It has a wavelength of 658nm. Which atomic transition is responsible for the H_α line?

A	B	C	D	E
$n = 3 \to 4$	$n = 3 \to 2$	$n = 2 \to 3$	$n = 3 \to 1$	$n = 4 \to 3$

$c = 3 \times 10^8$ ms^{-1}, $e = 1.6 \times 10^{-19}$ C, $h = 6.63 \times 10^{-34}$ m^{2}kgs^{-1}

Solution: B : $n = 3 \to 2$. Equating the change in E_n to $\frac{hc}{\lambda}$ gives $n = 3, 2$ as the pair of levels that work. Make sure to choose the emission, rather than absorption, transition.