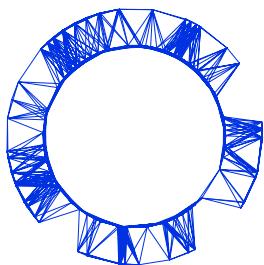


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## Detailed Marking Scheme Theory Problem 2

Where is the neutrino?

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v1.2

## Where is the neutrino? (10 points)

### Part A. ATLAS Detector physics (4.0 points)

#### A.1

Magnetic force as centripetal force	0.2
Velocity in terms of the kinetic energy	0.2
Final expression for the radius	0.1
Total	0.5

#### A.2

Recognize that $m \rightarrow \gamma m$	0.2
Expression for $p$	0.1
Radius of the circular motion is half the radius of the inner part of the detector	0.1
Final numerical expression for $p$	0.1
Total	0.5

#### A.3

Acceleration for the particle	0.2
Replace $a$ in the given expression for $P$	0.2
Use $E = \gamma mc^2$	0.2
Final expression for $P$ with identification of $\xi, n, k$	0.4
Total	1.0

#### A.4

Power emitted by the particle	0.3
Solve the integral to get $\frac{1}{E(t)} - \frac{1}{E_0} = \alpha t$	0.4
Arrive at expression for $E(t)$ and identify $\alpha$	0.3
Total	1.0

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**A.5**

Electron moving in a straight line	0.1
Time of flight	0.1
Expression for the energy lost	0.2
Final numerical value for energy lost	0.1
Total	0.5

**A.6**

$v \simeq c$ (ultrarelativistic limit)	0.1
$E \simeq pc$ (ultrarelativistic limit)	0.1
Expression for the frequency	0.3
Total	0.5

**Part B. Finding the neutrino (6.0 points)****B.1**

Expression for $\vec{p}^{(W)}$	0.3
Expression for $E^{(W)}$	0.3
Write the initial expression for $m_W^2$	0.3
Arrive at the final expression for $m_W^2$	0.6
Total	1.5

**B.2**

Numerical values for $p^{(\mu)}$ , $m_W^2 c^2$ , $p_T^{(\nu) 2}$ , $\vec{p}_T^{(\mu)} \cdot \vec{p}_T^{(\nu)}$ , $p_z^{(\mu)}$ (0.2 points each)	1.0
Get the two numerical solutions of the quadratic equation	0.5
Total	1.5

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## B.3

Expression for $E^{(t)}$	0.1
Expression for $\bar{p}^{(t)}$	0.1
Write the initial expression for $m_t$	0.2
Arrive at the two possible masses	0.6
Total	1.0

## B.4

Estimate the probability for the lighter mass	0.3
Estimate the probability for the heavier mass	0.3
Conclude about the most likely candidate	0.4
Total	1.0

## B.5

Numerical value for $E^{(t)}$	0.4
Analytical expression for $d$	0.4
Numerical value for $d$	0.2
Total	1.0

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