# EuPhO 2019 Theory 2 Marking Scheme

| Criteria | Max | Points |
|---|---|---|
| States that the work of the magnetic force and the force of static friction is zero | 0.5 | |
| Concludes that the speed (i.e. the magnitude of velocity) of the center of the ball is constant. | 0.5 | |
| Realizes that the force of static friction is perpendicular to the velocity. If the reasoning is physically wrong, 0 p. | 0.5 | |
| Concludes that the trajectory is circular. | 0.5 | |
| By using the condition of pure rolling derives kinematic relation between the horizontal ($\omega$), vertical ($\Omega$) components of the angular velocity and $v$. (0.5 p+0.5 p) | 1.0 | |
| Proves that the net Lorentz force is $QvB$. (No marks for the formula without proof.) | 0.5 | |
| Writes down Newton's second law in radial direction correctly. If either the Lorentz force or the frictional force is missing 0 p. | 0.5 | |
| Writes down an expression for the horizontal component of the angular momentum $L$. | 0.5 | |
| Realizes that the horizontal component of $L$ precesses with angular velocity $\Omega$ | 1.0 | |
| Writes down equation relating the rate of change of $L$ and the net torque. If either the torque of the friction or torque of magnetic field is missing, 0 p. If it does not use vectors, 0 p. | 1.0 | |
| Derives a relationship between the angular momentum of the ball and its magnetic moment. In case of a missing factor 1.5 p, in case of dimensional error 0.5 p, in case of physically wrong result (i.e. the torque is zero) or physically wrong reasoning 0 p. | 2.0 | |
| Writes down an expression for the torque of the magnetic forces ($\vec{\tau}_B = \vec{\mu} \times \vec{B}$ or equivalent expression) | 0.5 | |
| Writes down an equation for the torque of the static friction | 0.5 | |
| Solves the physically correct equations of motion and the kinematic equations and obtains expression for either $\Omega$ or the radius $r$ of the trajectory. If vectors were not used, 0 p. | 0.5 | |
| **Total** | **10.0** | |