Spring 2006 Qualifying Examination - Super-basic.

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1. [34 points total] Space-station elevator

Consider a rope placed in orbit radially on the plane of the Earth's equator. The rope moves along with the Earth so it appears from the Earth as hanging vertically above the surface of the Earth. Assume the mass per unit length is constant and equal to $\rho = 0.1$ kg/m. Neglect any effect of the Earth's atmosphere and self gravity of the rope. $R_{\text{Earth}} = 6.4 \times 10^6$ m; $M_{\text{Earth}} = 6.0 \times 10^{24}$ kg.

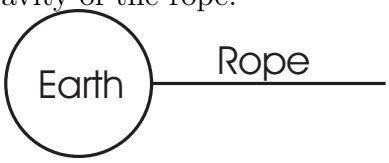

FIG. 1: *Rope above surface of Earth.*

A. [**17** points] Calculate the length of the rope.

B. [**17** points] Calculate the maximum tension on the rope.

2. [33 points total] Neutron interferometry

Consider a neutron interferometry experiment in which unpolarized neutrons with velocity $v = 500$ m/s (magnetic moment $\mu = -1.91\mu_N$, with $\mu_N = 3.15 \times 10^{-14}$ MeV/T) follow the paths shown in the figure. On one of the paths there is a section of length $\ell = 10$ cm where there is a uniform magnetic field of strength B pointing vertically up from the drawing.

A. [**5** points] Calculate the angle of precession as a function of the magnetic field intensity, B, assuming the neutron is a classical particle with spin angular momentum equal to $\hbar/2$ (this assumption holds only for this part of the problem.)

B. [**5** points] Assuming the neutron is a spin-$\frac{1}{2}$ particle, make a sketch of the neutron intensity detected at the detector as a function of magnetic field intensity, B.

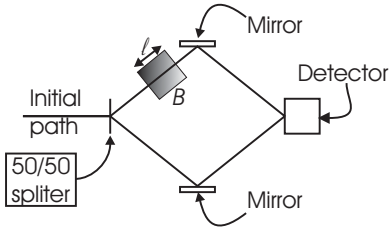

FIG. 2: *Sketch of neutron interferometry experiment.*

C. [**10** points] Determine the difference in magnetic field intensities, ΔB, between two minima of interference.

D. [**6** points] How would your answer to **2.C** change if the neutrons were fully polarized in the direction of the field?

E. [**7** points] How would your answer to **2.C** change if the neutrons are replaced by spin-1 particles with the same magnetic moment as the neutrons?

3. [33 points total] Relativity

A. [**13** points] Consider a neutral particle initially moving at $c/2$ in the x direction. A constant force in the y direction is applied. Make a sketch of the trajectory of the particle. In particular, indicate the asymptotic value of v_y/v_x as $v_y \to c$. Explain.

B. [**20** points] Anna has passed Bob at $0.8c$ going east. After 2 yrs, according to Bob, Carl passes Bob going east at $0.9c$. According to Carl, what is the time that elapses from the moment Carl passes Bob to the moment Carl passes Anna?