

### Answer on Question #78048 Physics / Other

The nuclear force between two neutrons in a nucleus is described by the Yukawa potential  $U(r) = -U_0 r_0 / r \exp(-r/r_0)$  where  $r$  is the distance between neutrons and  $U_0$  and  $r_0$  are constants. Determine the force  $\mathbf{F}(\mathbf{r}) = -\nabla U(r)$ .

**Solution:**

The force between two neutrons in a nucleus

$$\begin{aligned}\mathbf{F}(r) &= -\nabla U(r) = U_0 r_0 \nabla \left[ \frac{\exp\left(-\frac{r}{r_0}\right)}{r} \right] = U_0 r_0 \left[ -\frac{\exp\left(-\frac{r}{r_0}\right)}{r_0 r} \hat{\mathbf{r}} - \frac{\exp\left(-\frac{r}{r_0}\right)}{r^2} \hat{\mathbf{r}} \right] \\ &= -U_0 \exp\left(-\frac{r}{r_0}\right) \left[ \frac{1}{r} + \frac{r_0}{r^2} \right] \hat{\mathbf{r}},\end{aligned}$$

where  $\hat{\mathbf{r}} = \mathbf{r}/r$

**Answer:**  $\mathbf{F}(r) = -U_0 \exp\left(-\frac{r}{r_0}\right) \left[ \frac{1}{r} + \frac{r_0}{r^2} \right] \hat{\mathbf{r}}.$

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