UT Rio Grande Valley August 24, 2021
PHYS-3305 Classical Mechanics Andreas Hanke

Problem Set 1 – due Friday, September 3 by 12:00 PM midnight

The Problem Set has **6 questions** on **2 pages**, with a total maximum credit of **30 points**. Please turn in well-organized, clearly written solutions (no scrap work). All questions are taken from the textbook.

Problem 1.6 (page 35) "By evaluating their dot product ... " [4 points]

Problem 1.8, part (b) (page 35) "(b) If **r** and **s** are vectors that depend on time ... " [4 points]

Hint: Use the product rule for derivatives of the terms $r_i(t)s_i(t)$ in $\mathbf{r}(t)\cdot\mathbf{s}(t)=\sum_{i=1}^{3} r_i(t)s_i(t)$. (You don't need to write the argument (t) explicitly every time, but it's done here for clarity.)

Problem 1.10 (page 35) "A particle moves in a circle ... " [4 points]

In addition to answering the questions asked in the textbook, make a figure that shows the instantaneous position vector $\mathbf{r}(t)$, velocity vector $\mathbf{v}(t)$, and acceleration vector $\mathbf{a}(t)$.

Problem 1.13 (page 35) "Let **u** be an arbitrary fixed unit vector ... " [4 points]

Hint: Calculate the r.h.s. of the equation and show that it's equal to b^2. To this end, use $(\mathbf{u}\cdot\mathbf{b})^2=|\mathbf{u}\cdot\mathbf{b}|^2$, $(\mathbf{u}\times\mathbf{b})^2=|\mathbf{u}\times\mathbf{b}|^2$, $|\mathbf{u}|^2=1$, and $\cos^2(\theta)+\sin^2(\theta)=1$ where θ is the angle between $\mathbf{u}$ and $\mathbf{b}$.

Problem 1.17, part (b) (page 36) "(b) Prove the product rule ... " [7 points]

Hint: Use $\mathbf{r}\times\mathbf{s}=\sum_{i=1}^{3}(\mathbf{r}\times\mathbf{s})_i\,\hat{\mathbf{e}}_i=\sum_{i=1}^{3}\left(\sum_{j=1}^{3}\sum_{k=1}^{3}\varepsilon_{ijk}r_j s_k\right)\hat{\mathbf{e}}_i\equiv\sum_{ijk}\varepsilon_{ijk}r_j s_k\hat{\mathbf{e}}_i$ and use the product rule for derivatives, similarly as in Problem 1.8 part (b) above; note that $\hat{\mathbf{e}}_i$ is independent of t.

Problem 1.19 (page 37) "If **r**, **v**, **a** denote the position, velocity, and acceleration ... " [7 points]

Hint: Use $\mathbf{a}\cdot(\mathbf{v}\times\mathbf{r}) = \sum_{i=1}^{3} a_i (\mathbf{v}\times\mathbf{r})_i = \sum_{i=1}^{3} a_i \left(\sum_{j=1}^{3}\sum_{k=1}^{3} \varepsilon_{ijk} v_j r_k \right) \equiv \sum_{ijk} \varepsilon_{ijk} a_i v_j r_k$.

Use the product rule for derivatives, similarly as in Problems 1.8 part (b) and 1.17 part (b) above. Transform the resulting terms back to vector notation, and use that, for general vectors $\mathbf{b}$ and $\mathbf{c}$, the vector product $\mathbf{b}\times\mathbf{c}$ is perpendicular to both $\mathbf{b}$ and $\mathbf{c}$.