

Homework No. 06 (Spring 2024)

PHYS 205A-001: UNIVERSITY PHYSICS

School of Physics and Applied Physics, Southern Illinois University–Carbondale

Due date: Monday, 2024 Feb 19, 12:00 PM, on D2L

Instructions

- You are encouraged to use any of the resources to complete this homework. However, the extent to which you depend on resources while doing this homework is a measure of how much extra work you need to put in to master the associated concepts. Solutions should be the last resource.
- Links to solutions are provided. Further, links to few variations of the problem are provided that serve as practice problems.
- Describe your thought process in detail and organize it clearly. Make sure your answer has units and right number of significant digits.
- After completion, scan the pages as a single PDF file, and submit the file on D2L (under Assesments → Assignments). You can replace your PDF file, only the last file is graded.

Problems

1. (10 points.) A vinyl record on a turntable rotates at $33\frac{1}{3}$ revolutions per minute.
 - (a) What is its angular speed in radians per second?
 - (b) What is the linear speed of a point on the record at the needle when the needle is 15 cm from the turntable axis?
 - (c) What is the linear speed of a point on the record at the needle when the needle is 7.4 cm from the turntable axis?

[Solution]

2. (10 points.) Earth rotates about its axis once in 24 hours. Radius of Earth is 6400 km. Earth is spherical to a good approximation.
 - (a) Compute the magnitude and direction of the centripetal acceleration at the equator, due to rotation of Earth.
 - (b) Compute the magnitude and direction of the centripetal acceleration at the North pole, due to rotation of Earth.

- (c) Compute the magnitude and direction of the centripetal acceleration at Carbondale (at a latitude of 38° N) due to rotation of Earth.

[Solution, 2021S MT-02 P07, 2021S FE P06]

3. (10 points.) The International Space Station (ISS) orbits Earth with a time period of 93 minutes at an altitude of 420 km. Radius of Earth is 6400 km.
- (a) Compute the frequency of ISS. Or, how many times does the ISS orbit Earth in a day?
- (b) Compute the angular frequency of ISS.
- (c) Compute the orbital speed of ISS.
- (d) Compute the centripetal acceleration of ISS. How will a crew member perceive this acceleration? Compare this number to the acceleration due to gravity on the surface of Earth ($g = 9.8 \text{ m/s}^2$).

[Solution]

4. (10 points.) A ball swings counterclockwise in a vertical circle at the end of a rope 1.00 m long. When the ball is 40.0° past the lowest point on its way up, its total acceleration is

$$(-20. \hat{\mathbf{i}} + 15 \hat{\mathbf{j}}) \frac{\text{m}}{\text{s}^2}. \quad (1)$$

For that instant determine the following.

- (a) Sketch a vector diagram showing the components of its acceleration, both the $\hat{\mathbf{i}}\text{-}\hat{\mathbf{j}}$ basis and in the $\hat{\mathbf{r}}\text{-}\hat{\boldsymbol{\phi}}$ basis.
- (b) Determine the angle between the acceleration vector and the radial direction at the instant.
- (c) Show that the acceleration in the $\hat{\mathbf{r}}\text{-}\hat{\boldsymbol{\phi}}$ basis at the instant is

$$(-24 \hat{\mathbf{r}} - 5.6 \hat{\boldsymbol{\phi}}) \frac{\text{m}}{\text{s}^2}. \quad (2)$$

Then, read out the magnitude of its radial acceleration,

- (d) Determine the magnitude of the velocity of the ball.

[Solution]