

Physics 221

Quiz 2 — chapter 2, Form: A

Name: _____

Date: _____

$G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$
$c = 3 \times 10^8 \text{ m/s}$
$M_{\text{earth}} = 6.0 \times 10^{24} \text{ kg}$
$R_{\text{earth}} = 6.38 \times 10^6 \text{ m}$

Questions 1–3: State your answers to the following questions mathematically. Your answers must be exactly correct and all vector quantities should be written with an arrow above the variable.

1. What is the definition of velocity?

2. What is the definition of momentum?

3. What is the momentum principle?

Questions 4–7: An object of mass m travels around a circle of radius r with a constant speed $|\vec{v}|$.

4. What is the speed of the object in terms of the radius of the circle r and the period T ?

5. What is the magnitude of the net force on the object at any instant of time, assuming that the speed of the object is much less than the speed of light?

6. If the object in question is a satellite in a circular orbit around a much more massive planet of mass M such that the net force on the satellite is equal to the gravitational force of the planet on the satellite, what is the speed of the satellite?
7. For the satellite in the previous question, what is its period in terms of the radius of its orbit and the mass of the planet?

Questions 8–9: The great marathoner Bridget Mears and a friend both run at constant speed around a semi-circular track such that they both travel around the track in the same time T . Bridget's speed is $|\vec{v}_1|$. Being a student of physics, Bridget knows to take the inside lane while her friend takes the outside lane. Their paths are shown below.

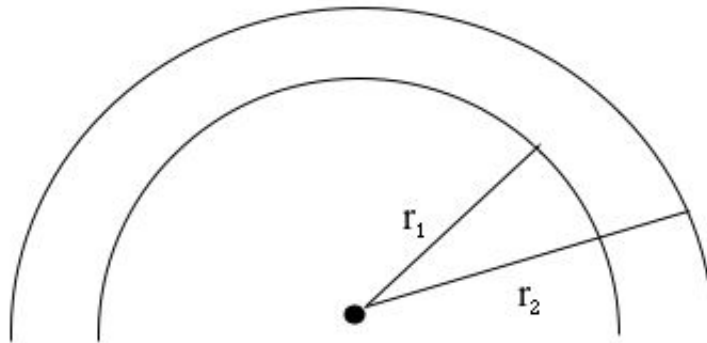


Figure 1:

8. If her friend's radius is $1.5r_1$, what is her friend's speed?
- (a) $|\vec{v}_1|/1.5$
 - (b) $2.25|\vec{v}_1|$
 - (c) $|\vec{v}_1|/2.25$
 - (d) $1.5|\vec{v}_1|$
 - (e) It cannot be determined from the given information.

9. Suppose that instead, Bridget and her friend run at the same speed around the curve. Which one gets to the end of the curve first? What is this person's time compared to the other person's time?
- (a) Bridget, $T_1 = T_2/1.5$
 - (b) her friend, $T_2 = T_1/1.5$
 - (c) Bridget, $T_1 = T_2/2.25$
 - (d) her friend, $T_2 = T_1/2.25$
 - (e) They get there in the same time.
10. Suppose that Bridget runs at a speed of 12 m/s around the curve of radius 12 m. What is the magnitude of the net force on her at any instant around the curve and in what direction is it when she is half way around the curve? Assume that her mass is 50 kg.
11. What forces are acting on her as she is running and what "object" exerts the force that is primarily responsible for the net force pointing toward the center? (You don't have to draw pictures but you may.)

12. A satellite orbiting the moon is located at the position shown. If the Earth is the origin, and the moon is at $\langle 3.33 \times 10^8, 1.92 \times 10^8, 0 \rangle$ and the satellite is at $\langle 3.39 \times 10^8, 1.89 \times 10^8, 0 \rangle$. What is the gravitational force of the moon on the satellite? (Note: express this as a vector and sketch it on the diagram.) The mass of the moon is $M_{moon} = 7.35 \times 10^{22}$ kg and the mass of the satellite is 1×10^5 kg.

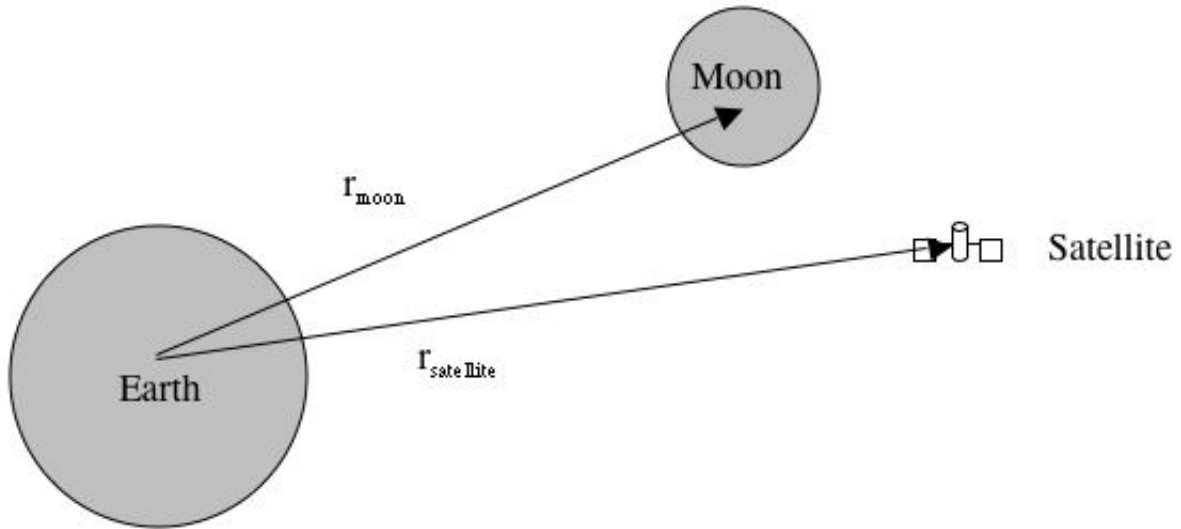


Figure 2:

Answer Key for Exam A

1.

$$\vec{v} = \frac{\Delta \vec{r}}{\Delta t}$$

2.

$$\vec{p} = m\vec{v}$$

3.

$$\vec{F}_{net} = \frac{\Delta \vec{p}}{\Delta t}$$

4.

$$|\vec{v}| = 2\pi r/T$$

5.

$$|\vec{F}_{net}| = m|\vec{v}|^2/r$$

6.

$$|\vec{v}| = \sqrt{GM/r}$$

7.

$$T^2 = 4\pi^2/(GM) * r^3$$

8. (d)

9. (c)

10.

$$|\vec{F}_{net}| = mv^2/r = 50(12)^2/12 = 600 \text{ N}$$

11. The two forces on her are gravitation and the track. A component of the force of the track points toward the center (friction actually) of the circle; therefore, it's the force of the track on her that keeps her in a circular path.

12.

$$\begin{aligned}\vec{r} &= \vec{r}_{moon} - \vec{r}_{sat} = \langle -0.06, 0.03, 0 \rangle \times 10^8 \text{ m} \\ \hat{r} &= \langle -0.90, 0.45, 0 \rangle \\ r &= 6.7 \times 10^6 \text{ m} \\ \vec{F}_{grav} &= \frac{GMm}{r^2} \hat{r} = 1.1 \times 10^4 \langle -0.90, 0.45, 0 \rangle \text{ N}\end{aligned}$$