

Physics 221

Quiz 4, Form: A

Name: _____

Date: _____

Here are some useful constants. R is radius.

$M_{earth} = 6.0 \times 10^{24} \text{ kg}$
$R_{earth} = 6.38 \times 10^6 \text{ m}$

-
1. State the momentum principle in words.
 2. State the momentum principle mathematically.
 3. For an object moving in circular motion at constant speed, the direction of the net force on the object is always
 - (a) tangent to the path
 - (b) in the radial direction away from the center of the circle
 - (c) in the radial direction toward the center of the circle
 4. The momentum of an object (along any path whether it's a line, ellipse, circle, parabola, etc.) is always
 - (a) tangent to the path.
 - (b) in the radial direction away from the center of the circle.
 - (c) in the radial direction toward the center of the circle.
 - (d) in the direction of the net force on the object.

Questions 5– 7: Suppose you are doing an experiment in an environmental science class where you swing a device that is mounted in on a string and as it swings around it collects particulate matter in the air. It's important to measure it speed and period because this is related to how much matter it can collect. Model the device as if it travels in a circular path at constant speed.

5. If it makes 5 revolutions in 20 seconds, what is its period (time interval for one revolution)?
 - (a) 0.25 s
 - (b) 4 s
 - (c) 5 s
 - (d) 20 s
 - (e) 100 s
6. What is its angular speed, ω , in rad/s?
 - (a) 25.1 rad/s
 - (b) 1.26 rad/s
 - (c) 0.063 rad/s
 - (d) 0.314 rad/s
 - (e) 1.57 rad/s

7. What is the speed, v , of the device if its distance from the center of the circle is 2 m?
- 50.2 m/s
 - 2.52 m/s
 - 0.126 m/s
 - 0.628 m/s
 - 3.14 m/s
8. Suppose that satellite A is in a circular orbit about the earth and has a period T_A . If satellite B is in a circular orbit at a radius $r_B = 3r_A$, what would be its period?
- $T_B = 3T_A$
 - $T_B = (1/3)T_A$
 - $T_B = 9T_A$
 - $T_B = (1/9)T_A$
 - $T_B = 5.2T_A$
9. You ride a roller-coaster that travels around a vertical loop. Model the motion as circular motion at constant speed. The magnitude of the net force on you is 700 N and the gravitational force of the earth on you is of magnitude 650 N. What is the direction of the force of the seat (and harness) on you when you are at the top?
- downward
 - upward
10. What is the direction of the force of the seat (and harness) on you when you are at the bottom?
- downward*
 - upward*
11. What is the force of the seat on you when you are at the bottom of the loop?
- $\langle 0, 50, 0 \rangle$ N
 - $\langle 0, 1350, 0 \rangle$
 - $\langle 0, -50, 0 \rangle$ N
 - $\langle 0, -1350, 0 \rangle$
12. What is the force of the seat on you when you are at the top of the loop?
- $\langle 0, 50, 0 \rangle$ N
 - $\langle 0, 1350, 0 \rangle$
 - $\langle 0, -50, 0 \rangle$ N
 - $\langle 0, -1350, 0 \rangle$

Questions 13– 14: The space shuttle orbits the Earth at an altitude of about 200 mi (1 mi = 1620 m). Its distance from the center of the earth is the radius of the earth plus its altitude.

13. What is the period of its orbit?

14. How fast is the space shuttle moving (v)?

Questions 15– 16: A comet's orbit is shown in Figure 1. Use arrows of appropriate lengths to show the net force on the comet and the direction of the momentum of the comet at each of the labeled points. (Appropriate lengths means that larger magnitudes are represented by longer vectors.)

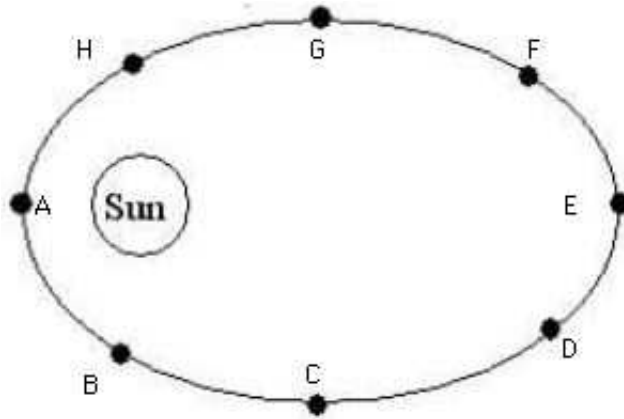


Figure 1: Orbit of a comet.

15. At which point is the net force on the comet the greatest? At which point is it the smallest?

16. At which point is the momentum of the comet the greatest? At which point is it the smallest?

17. Your lab partner is reviewing the VPython program you wrote in lab to simulate the orbit of a planet around a star. Your program is shown below.

```
from visual import *
G = 6.7e-11
deltat = 60*60*3
t = 0

star = sphere(pos=vector(0,4e11,0), radius=8e10, color=color.yellow)
star.mass = 1.3e31
planet = sphere(pos=vector(9e11,0,0), radius=5e10, color=color.cyan)
planet.mass = 8e25
planet.p = planet.mass * vector(0,3.5e4,0)

planet.trail = curve(color=planet.color)
while t < 1e9:
    r = star.pos - planet.pos
    rmag = sqrt(r.x**2 + r.y**2 + r.z**2)
    rhat = r/rmag
    Fmag = G*planet.mass*star.mass/rmag**2
    Fnet = Fmag*rhat
    planet.p = planet.p + Fnet*deltat
    planet.pos = planet.pos + (planet.p/planet.mass)*deltat
    planet.trail.append(pos=planet.pos)
    t = t + deltat
```

What is the initial momentum of the planet? Express as a vector with units.

18. What is the time interval between updates of the position, in hours?

Answer Key for Exam A

1. The change in momentum of an object is equal to the net force on the object times the time interval during which the net force acts.

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

3. (c)

8. (e)

4. (a)

9. (a)

5. (b)

10. (b)

6. (e)

11. (b)

7. (e)

12. (c)

13. $r = 6.704 \times 10^6$

$$v = \sqrt{\frac{GM}{r}}$$

$$v = \frac{2\pi r}{T}$$

$$T = 2 * \pi \frac{r^{3/2}}{\sqrt{GM}} = 5440 \text{ s}$$

14. $v = \frac{2\pi r}{T} = 7740 \text{ m/s}$

15. greatest – A; least – E

16. greatest–A; least–E

17. $\vec{p} = m\vec{v} = \langle 0, 2.8e30, 0 \rangle \text{ kg m/s}$

18. 3 hours