Physics 151
March 17, 2006

Roster No.:__________________________

Score:______________________________

Midterm Exam #2, Part A

Exam time limit: 50 minutes. You may use calculators and both sides of ONE sheet of notes, *handwritten only.* Closed book; no collaboration. For multiple choice questions, circle the one best answer or letter (unless more than one answer is asked for).

<u>*Physical constants:*</u> $g = 9.81\ \text{m/s}^2$ $G = 6.67 \times 10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2$

<u>*Useful conversions:*</u> $1\ \text{y} = 3.156 \times 10^7\ \text{s}$

1. (8 pts.) **Convert** the following quantities into the units specified. Fill in the blanks. (You do NOT need to show your work.) Use *scientific notation* where appropriate (very large or very small values), and express all final values to *3 significant figures*.

a. 13.8 Gy = __________________________ s (see conversion factor above for years [y] to seconds.)

b. 5.35×10^{14} Hz = ____________________ THz

c. $0.0794\ \text{m}^3$ = ________________________ cm^3

d. $1.11\ \text{g}\cdot\text{cm/s}^2$ = ______________________ N

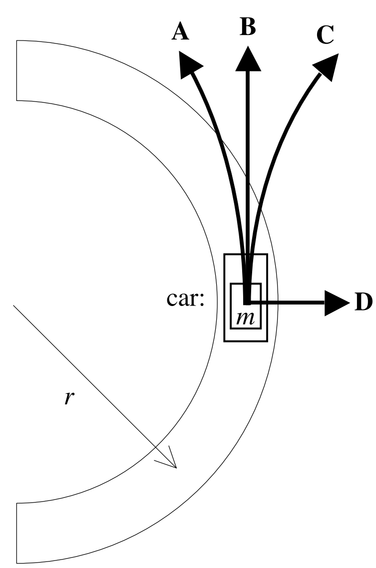
2. a. (2 pts.) A car of mass *m* rounds a left-hand circular turn with radius *r*. If the road is *level* (unbanked), and the car proceeds around the turn at constant linear speed v, what must be the **minimum value of μ_s** for the car to stay on the road and successfully execute the curve?

A. $\dfrac{vg}{r}$ D. $\dfrac{v}{gr}$

B. $\dfrac{v^2 g}{r}$ E. $\dfrac{v^2}{gr}$

C. $\dfrac{vg}{r^2}$ F. $\dfrac{v}{gr^2}$

b. (1 pt.) If the car suddenly encounters an icy portion of the road (at the moment shown here) and μ_s instantly becomes zero, what will be the subsequent **path** of the car? ***Circle the ONE correct letter on the diagram at right:***



3. A washing machine on "spin" cycle spins at approximately 4.0 Hz when it gets up to full speed.

a. (2 pts.) How much **time** is needed for the machine to make one rotation at this speed?

A. 2.5 ms
B. 4.0 ms
C. 25 ms
D. 40. ms
E. 85 ms
F. 0.25 s
G. 0.40 s
H. 0.85 s

b. (3 pts.) If the washing machine's interior is essentially a hollow cylinder of radius 0.25 m, what is the **centripetal acceleration** felt by the spinning clothes pressed against the inside edge?

A. 0.063 times *g*
B. 0.41 times *g*
C. 2.6 times *g*
D. 5.1 times *g*
E. 8.1 times *g*
F. 12 times *g*
G. 16 times *g*
H. 41 times *g*

4. (2 pts.) Which one of the following is **TRUE**?

A. The gravitational force of the Moon on the Earth is much smaller than that of the Earth on the Moon.
B. The Moon is falling (accelerating) toward the Earth.
C. The Moon's linear (tangential) speed constantly increases over time.
D. If the mass of the Earth suddenly doubled, the Moon's orbital speed would be unaffected.

5. (1 pt.) Kepler's Second Law states that the imaginary line connecting the Sun and a planet sweeps out equal amounts of area in equal intervals of time. As a result, the linear **speed** of a planet in an elliptical orbit …

A. must be constant at all points throughout its orbit.
B. is slowest in the part of its orbit closest to the Sun, and fastest when farthest from the Sun.
C. is fastest in the part of its orbit closest to the Sun, and slowest when farthest from the Sun.
D. is fastest in the parts of its orbit closest to and farthest from the Sun, and slowest in between.

6. (2 pts.) A laser with a power of 3.0 MW generates a pulse of light for 5.0 ms. What is the total **energy** contained in the pulse?

A. 0.60 J
B. 1.7 J
C. 15 J
D. 85 J
E. 600 J
F. 1.7 kJ
G. 15 kJ
H. 85 kJ

7. (1 pt.) An object slides down a stationary ramp. The **kinetic friction force** on the object…

A. always points perpendicular to the surface of contact
B. always points opposite to the direction of the object's velocity
C. has a magnitude that is proportional to the speed of the object
D. has a magnitude that is proportional to the acceleration of the object

8. (8 pts.) Two identical masses m on Earth and Mars are both dropped from rest, and both fall through identical heights h. (Ignore air resistance.) Suppose, for simplicity, that $g_{\text{Mars}} = \frac{1}{3} g_{\text{Earth}}$ exactly.

a. The **weight** of the Earth mass is ________ times the weight of the Mars mass.

A. 1/9 D. $\sqrt{3}$
B. 1/3 E. 3 G. 1 (the same for both masses)
C. $1/\sqrt{3}$ F. 9

b. $\boldsymbol{\Delta U_{\text{gr}}}$ for the Earth mass is ________ times ΔU_{gr} for the Mars mass.

A. 1/9 D. $\sqrt{3}$
B. 1/3 E. 3 G. 1 (the same for both masses)
C. $1/\sqrt{3}$ F. 9

c. $\boldsymbol{\Delta K}$ for the Earth mass is ________ times ΔK for the Mars mass.

A. 1/9 D. $\sqrt{3}$
B. 1/3 E. 3 G. 1 (the same for both masses)
C. $1/\sqrt{3}$ F. 9

d. The **final speed** of the Earth mass is ________ times the final speed of the Mars mass.

A. 1/9 D. $\sqrt{3}$
B. 1/3 E. 3 G. 1 (the same for both masses)
C. $1/\sqrt{3}$ F. 9

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Midterm Exam #2, Part B

Show your work on free-response questions. Be sure to use **proper units** and **significant figures** in your final answers.

Physical constants:	$g = 9.81\ \text{m/s}^2$	$G = 6.67 \times 10^{-11}\ \text{N·m}^2/\text{kg}^2$	
Useful conversions:	$1\ \text{y} = 3.156 \times 10^7\ \text{s}$		
Sun, Earth, & Moon data:			
masses	*radii*	*orbital distances*	*orbital periods*
$M_{\text{Sun}} = 2.00 \times 10^{30}$ kg	$R_{\text{Sun}} = 6.95 \times 10^8$ m		
$M_{\text{Earth}} = 5.97 \times 10^{24}$ kg	$R_{\text{Earth}} = 6.37 \times 10^6$ m	$d_{\text{Earth-Sun}} = 1.50 \times 10^{11}$ m	$T_{\text{Earth}} = 1.00$ year
$M_{\text{Moon}} = 7.35 \times 10^{22}$ kg	$R_{\text{Moon}} = 1.74 \times 10^6$ m	$d_{\text{Earth-Moon}} = 3.84 \times 10^8$ m	$T_{\text{Moon}} = 27.3$ days

1. a. (6 pts.) "Geosynchronous" satellites are especially useful for telecommunications, since they orbit the Earth with a period of 1.00 day. (This makes them appear to hover above a single point on the Earth's equator in a stationary fashion, giving them their name "geosynchronous.") Calculate the **orbital distance** from the center of the Earth for a geosynchronous satellite, assuming that its orbit is perfectly circular. Also, how many **times** $\boldsymbol{R_{\text{Earth}}}$ (the radius of the Earth) is your answer?

b. (4 pts.) The International Space Station orbits at a mean distance of only 1.06 R_{Earth} from the center of the Earth — far closer than a geosynchronous satellite. Assuming that both have perfectly circular orbits, which of the two orbiting objects …

i. … has the **longer period**?
- A. Space Station
- B. geosynchronous satellite
- C. same for both objects
- D. cannot determine from information given

ii. … has the **faster linear speed**?
- A. Space Station
- B. geosynchronous satellite
- C. same for both objects
- D. cannot determine from information given

iii. … has the greater **centripetal acceleration**?
- A. Space Station
- B. geosynchronous satellite
- C. same for both objects
- D. cannot determine from information given

iv. … feels the greater **gravitational force** from the Earth?
- A. Space Station
- B. geosynchronous satellite
- C. same for both objects
- D. cannot determine from information given

2. a. (5 pts.) Suppose that a 225-kg bobsled in last month's Winter Olympics starts a downhill run with an *initial speed* of 8.00 m/s. The sled descends a 45.0-meter-high hillside of varying slope. *Without friction or air resistance*, calculate the bobsled's **final speed** at the bottom of the hill:

b. (5 pts.) Now, suppose in real life that *friction* is present. The same bobsled starts with the same initial speed and descends the same hill as in part (a), but its *actual* final speed at the bottom of the hill is only 24.0 m/s. How much **energy** is **dissipated by friction** during descent? What **percentage** of the bobsled's total **initial energy** is this?