Physics 151
October 22, 2010

Roster No.:__________________________

Score:______________________________

Midterm Exam #2, Part A

Exam time limit: 50 minutes. You may use a calculator and both sides of ONE sheet of notes, *handwritten only*. Closed book; no collaboration. Ignore friction and air resistance in all problems, unless told otherwise.

Part A: For each question, fill in the letter of the one best answer on your bubble answer sheet.

Physical constants: $g = 9.80$ m/s^2 $G = 6.67 \times 10^{-11}$ N·m^2/kg^2
Useful conversions: 1 year $= 3.156 \times 10^7$ s
Sun, Earth, & Moon data:

masses	*physical radii*	*orbital distances*	*orbital periods*
$M_{Sun} = 2.00 \times 10^{30}$ kg	$R_{Sun} = 6.95 \times 10^8$ m		
$M_{Earth} = 5.97 \times 10^{24}$ kg	$R_{Earth} = 6.37 \times 10^6$ m	$d_{Earth\text{-}Sun} = 1.50 \times 10^{11}$ m	T_{Earth} = 1 year (exact)
$M_{Moon} = 7.35 \times 10^{22}$ kg	$R_{Moon} = 1.74 \times 10^6$ m	$d_{Earth\text{-}Moon} = 3.84 \times 10^8$ m	T_{Moon} = 27.3 days

(2 pts. each) **Convert** the following quantities into the given units:

1. 99 kW = ______________________ mW (*Note:* "W" = watt, the MKS unit for power)
A. 9.9×10^{-10} mW
B. 9.9×10^{-7} mW
C. 9.9×10^{-4} mW
D. 9.9×10^{4} mW
E. 9.9×10^{7} mW

2. 3.3×10^{11} m^3 = ________________________ km^3
A. 330 km^3
B. 3.3×10^3 km^3
C. 3.3×10^4 km^3
D. 3.3×10^5 km^3
E. 3.3×10^6 km^3

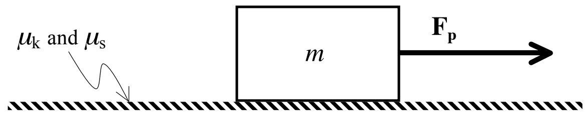
3. 25 cm/s = ______________________ km/h (*Note:* "h" = hour)
A. 9.0×10^{-3} km/h
B. 9.0×10^{-2} km/h
C. 0.90 km/h
D. 9.0 km/h
E. 90. km/h

Questions #4–5: A child's toy airplane flies in uniform circular motion at the end of a massless tether (cord). The plane of the circle is exactly *horizontal* (parallel to the ground). (*Neglect gravity and air resistance.*)

4. (1 pt.) The **acceleration** of the airplane is always…
A. tangent to the circle, in the direction of the airplane's velocity
B. exactly toward the center of the circle
C. exactly away from the center of the circle
D. zero

5. (2 pts.) The tether will break if its tension exceeds 95 N. If the length of the tether is 1.5 m, and the airplane has a mass of 0.20 kg, what is the toy airplane's **maximum linear speed**?
A. 11 m/s
B. 16 m/s
C. 22 m/s
D. 27 m/s
E. 34 m/s

Questions #6–8: A block of mass m initially sits *at rest* on a horizontal surface. The coefficients of friction between the block and the surface are μ_k and μ_s. A person pushes on the block with a *horizontal* force $\mathbf{F_p}$ in an attempt to dislodge it.



6. (2 pts.) What is the **minimum magnitude of $\mathbf{F_p}$** needed for the block to start sliding?

A. $\mu_k mg$ C. $\dfrac{mg}{\mu_k}$ E. $\dfrac{mg}{\mu_k + \mu_s}$

B. $\mu_s mg$ D. $\dfrac{mg}{\mu_s}$

7. (2 pts.) Later, suppose the block is sliding to the right. If the block has a rightward acceleration a, what is the **magnitude of $\mathbf{F_p}$**?

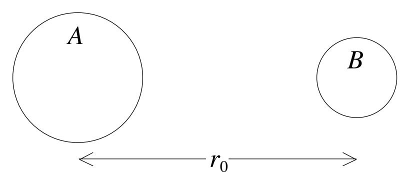
A. ma C. $m(a + \mu_k g)$ E. $\dfrac{ma}{\mu_k}$

B. $\mu_k ma$ D. $m(a - \mu_k g)$

8. (1 pt.) In the previous question, the person exerts a rightward force of F_p on the crate, and the crate accelerates to the right. *At the same time*, the **crate** exerts a **leftward force on the person** that is…

A. zero
B. weaker than F_p
C. equal to F_p
D. stronger than F_p

Questions #9–11: Consider two spherical masses, A and B, as shown, released *from rest* at an initial separation r_0. Mass A is larger than mass B. (*Assume that NO other masses exist in the universe.*)



9. (1 pt.) As the two masses fall toward each other, the gravitational **force** acting **on mass A** is ____________ the gravitational force acting **on mass B**, at all times.

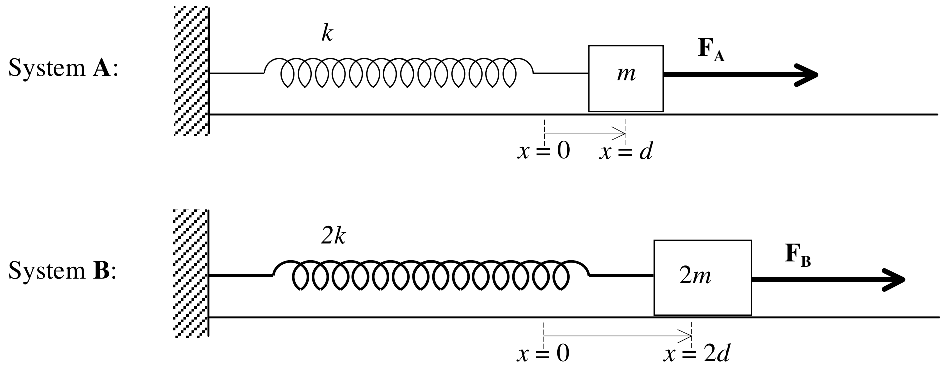
A. stronger than
B. equal strength as
C. weaker than
D. None of the above answers is true at all times.

10. (1 pt.) The two masses will finally collide at a **location**…

A. closer to the starting position of mass A
B. closer to the starting position of mass B
C. exactly halfway between their original positions

11. (1 pt.) Just before the two masses collide, the **speed** of mass A will be ____________ the speed of mass B.

A. faster than
B. equal to
C. slower than



Questions #12–16: Masses m and $2m$ are attached to ideal, massless springs, k and $2k$, respectively, as shown above. The mass in system A is initially pulled aside to a displacement of $x = d$, while the mass in system B is initially displaced *twice* as far. (*The surfaces are frictionless. The force vectors* $\mathbf{F_A}$ *and* $\mathbf{F_B}$ *are NOT necessarily drawn to scale*.)

For the next 3 questions, the two systems are held *at rest* by applying forces $\mathbf{F_A}$ and $\mathbf{F_B}$, respectively.

12. (1 pt.) For either system, a *complete* free-body diagram of mass m would show _____ **distinct force vectors** acting on m.

A. 1
B. 2
C. 3
D. 4
E. 5

13. (2 pts.) Suppose that $k = 55$ N/m, $m = 1.8$ kg, and $d = 7.5$ cm. What is the **magnitude** of force $\mathbf{F_A}$?

A. 2.9 N
B. 4.1 N
C. 6.5 N
D. 8.0 N
E. 9.2 N

14. (2 pts.) The magnitude of **force** $\mathbf{F_A}$ is __________ times the magnitude of **force** $\mathbf{F_B}$.

A. $\frac{1}{4}$
B. $\frac{1}{2}$
C. 1 (equal)
D. 2
E. 4

Now, both forces $\mathbf{F_A}$ and $\mathbf{F_B}$ are *removed* simultaneously, and both masses are free to move without friction.

15. (1 pt.) Immediately after release, both masses will return to $x = 0$ …

A. at constant speed
B. with increasing speed, but with diminishing acceleration
C. with increasing speed, and with constant acceleration
D. with increasing speed, and with strengthening acceleration

16. (2 pts.) *Immediately after release*, the mass's **acceleration** in **system** $\boldsymbol{A}$ is __________ times the mass's **acceleration** in **system** $\boldsymbol{B}$.

A. $\frac{1}{4}$
B. $\frac{1}{2}$
C. 1 (equal)
D. 2
E. 4

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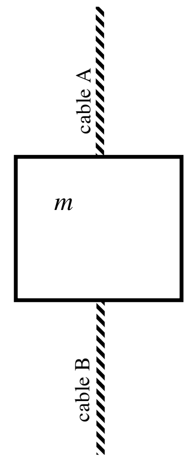
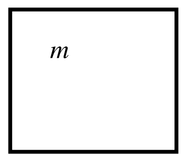
Midterm Exam #2, Part B

<u>Part B:</u> **Show your work** on all free-response questions. Be sure to use **proper units** and **significant figures** in your final answers. For any multiple-choice questions, circle the letter of the one best answer (unless more than one answer is asked for).

1. A large, heavy crate (m = 250.0 kg) is suspended on cable A from a crane. *At all times*, a worker pulls downward on cable B with a constant 380. N of force, to help guide and steady the crate. Both cables are exactly vertical. *Assume that both cables are massless and inelastic.*



a. (2 pts.) Using the crate shown at right, create a **free-body diagram** of m, showing **ALL forces** acting on it. **LABEL** ALL force vectors with names. *(You do NOT need to calculate their magnitudes for this diagram.)*



b. (2 pts.) If the crate is *at rest*, the **magnitude** of the **tension** in

cable A is: ____________________
You do NOT need to show your work for part (b).

c. (5 pts.) Later, while the crate is moving, the tension in cable A is measured to be 2750. N. (The worker is still applying 380. N of downward force on cable B.) Find the **magnitude** and **direction** of the crate's **acceleration**. *Show your work completely.*

2. In the not-too-distant future, astronauts may use Mars's larger moon, Phobos, as a location for a lunar base and way-station to Mars. Throughout this question, assume that Phobos is a uniform-density, perfectly smooth sphere with radius 1.11×10^4 m and mass 1.07×10^{16} kg. (*Ignore the presence of Mars or any other astronomical bodies.)*

Two astronauts, Adam and Beverly, are having a friendly argument: Adam bets Bev that he can throw a 145-gram baseball horizontally (tangent to the ground) fast enough to put it into a *circular orbit* just barely above the surface of Phobos. Bev is skeptical, so she does a quick calculation…

a. (5 pts.) Find the **linear speed** necessary for the baseball. *Show your work*. (*Thought question:* Could a human indeed throw a baseball this fast? *Recall:* 1 m/s ≈ 2.24 miles/hour.)

To prove his point, Adam does it: he throws the baseball at just the right speed, and away it goes in a circular orbit. While Adam stands grinning at Bev, the baseball circles Phobos completely and smacks him right in the helmet. Bev decides that it was worth the extremely long wait.

b. (5 pts.) How much **time** is needed for the baseball to complete one full orbit of Phobos? Convert your final answer to **hours**. *Show your work*. (*Hint: Your final answer will be between 1 and 3 hours.)*

continued on next page…

2. continued:

Repeat of earlier information: Assume that Phobos is a uniform-density, perfectly smooth sphere with radius 1.11×10^4 m and mass 1.07×10^{16} kg. (*Ignore the presence of Mars or any other astronomical bodies.)*

c. (1 pt.) If Adam had thrown the baseball horizontally with ***slightly*** **greater speed** than the speed calculated in part (a), what would have happened to the baseball's **orbit**?

A. There would be no change: the baseball would still execute an identical circular orbit just barely above the surface of Phobos, just with a faster speed.

B. The baseball would have ascended to a larger radius, then orbited Phobos in a larger circular orbit at that new radius, high above the surface.

C. The baseball would have orbited Phobos in a large ellipse: ascending for the first half of the orbit, then descending for the second half (striking Adam in the head as it grazes Phobos's surface on its return).

One of the challenging things about working and living on Phobos is the very weak surface gravity.

d. (5 pts.) Find the **acceleration due to gravity** on the surface of Phobos, and convert your final answer to **Earth "gees."** *Show your work.*