PHYSICS 251

FINAL EXAM - WINTER 2002

Name: ________________________ **SSN:** ________________________

CHECK ONE :

Carman	9:00 a.m.	____
Heremans	10:00 a.m.	____
Hicks	11:00 a.m.	____
Shields	2:00 p.m.	____

Note : Problems 1-18 are worth 2 points each; Problems 19-22 are worth 10 points each.

Only the 3 highest scores from questions 19-22 will be counted.

Please do not write below this line on the page. Happy Holidays, see you next year.

Total Page 1 _____

Total Page 2 _____

Total Page 3 _____

Total Page 4 _____

Total Page 5 _____

Total Page 6 _____

Total Page 7 _____

Question 19 _____

Question 20 _____

Question 21 _____

Question 22 _____

Total _____ out of 66

Part A – 2 Point Questions

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1). The speed of a particle in units of m/s is given by $v = 4t^2 - 4t - 8$, where t is in seconds. The acceleration of the particle is momentarily equal to zero at what time?

A. 0.1 s B. 0.5 s C. 3.3 s D. 5.0 s E. 6.2 s

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2). An object is thrown vertically upward. While it is rising:

A. Its velocity and acceleration are both upward.

B. Its velocity is upward and its acceleration is downward.

C. Its velocity and acceleration are both downward.

D. Its velocity is downward and its acceleration is upward.

E. Its velocity and acceleration are both decreasing.

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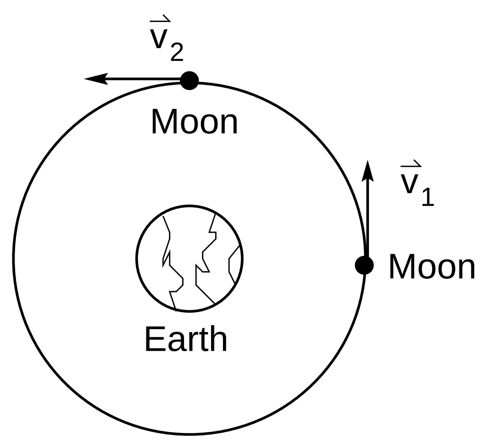
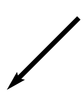
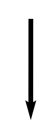
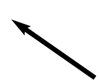
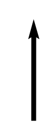
3). The figure shows the position of the moon at two times, about 7 days apart. Which vector best represents the *change* in the moon's velocity during this time?



A.  B. C.  D.  E. 

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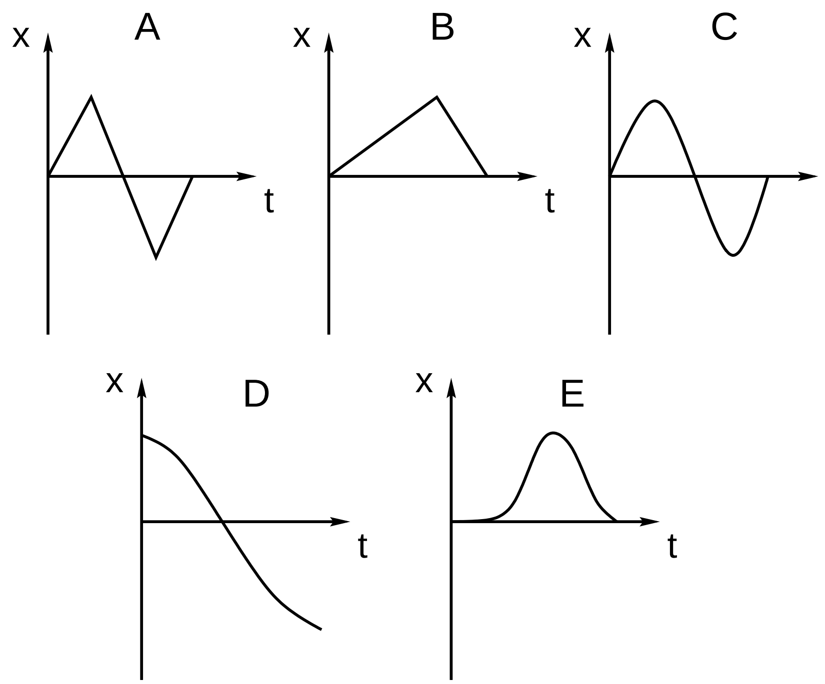
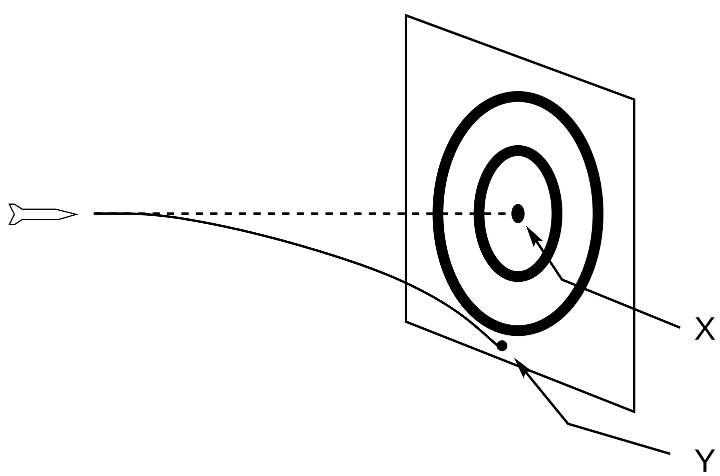
4). A car accelerates from rest on a straight road. A short time later, the car decelerates to a stop and then returns to its original position is a similar manner. Which of the five following graphs best describes the motion?



5). A dart is thrown horizontally toward X at 20 m/s as shown. It hits Y 0.10 s later. The vertical distance XY is:



A. 2.0 m B. 1.0 m C. 0.50 m D. 0.10 m E. 0.05 m

6). If a certain car, going with speed v, rounds a level curve with a radius R, it is just on the verge of skidding. If its speed is now doubled, the radius of the tightest curve on the same road that it can round without skidding is:

A. $2R$

B. $4R$

C. $R/2$

D. $R/4$

E. R

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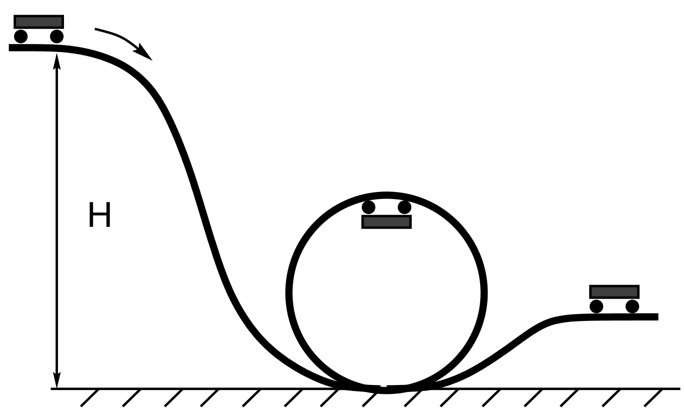
7). A roller coaster car of mass 1500 kg travels down a frictionless track, starting a distance H=23 m above the bottom of a loop as shown. If the loop is 15 m in diameter, the downward force of the rails on the car when it is upside down at the top of the loop is:



A. 4.6×10^4 N

B. 3.1×10^4 N

C. 1.7×10^4 N

D. 0.98 kN

E. 1.6×10^3 N

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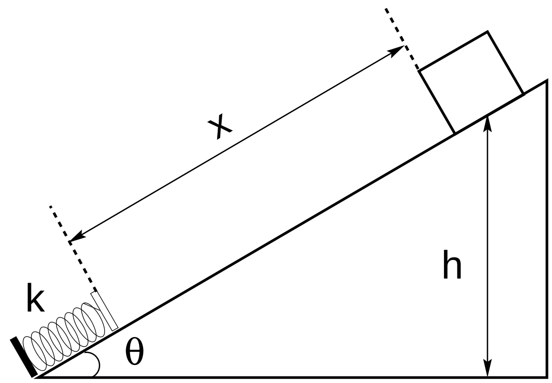
8). A block is placed on a frictionless incline as shown, and released. Which of the following statements is true?



A. The kinetic energy of the block just before it collides with the spring is equal to mgh.

B. The kinetic energy of the block at maximum compression of the spring is equal to mgh.

C. The kinetic energy of the block at maximum compression of the spring is zero.

D. The kinetic energy of the block just before it collides with the spring is $\frac{1}{2}kx^2$.

E. The kinetic energy of the block just before it collides with the spring is zero.

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9). Two disks are mounted on low-friction bearings on a common axis. The first disk has a rotational inertia I_0 and angular speed ω_0. The second disk has twice these values, $2I_0$ and $2\omega_0$. Both disks spin in the same direction. The two disks are forced together, with no external torque, until they couple and spin together with a common angular speed of:

A. $\sqrt{7/3}\,\omega_0$

B. $\sqrt{5/3}\,\omega_0$

C. $\sqrt{1/3}\,\omega_0$

D. $3\omega_0$

E. $(5/3)\omega_0$

10). The earth has a mass of 5.98×10^{24} kg. The moon has a mass of 7.36×10^{22} kg and is 3.84×10^{5} km from the earth. How far from the center of the earth is the center of mass of the earth-moon system?

A. 4.7×10^{3} km

B. 7.4×10^{3} km

C. 1.9×10^{3} km

D. 2.1×10^{3} km

E. 3.8×10^{3} km

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11). When (and if) George W. Bush assumes the presidency, he will reside in Washington D.C. while his brother Jeb Bush will reside in Florida. As the earth rotates, George W.'s linear velocity is _______ Jeb's, and George W.'s angular velocity is _______ Jeb's.

A. greater than; equal to

B. equal to; greater than

C. greater than; less than

D. less than; greater than

E. less than; equal to

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12). A horizontal shove of at least 50.0 N is required to start moving a crate weighing 200 N, initially at rest on a horizontal floor. The coefficient of static friction is:

A. 0.25

B. 0.125

C. 0.50

D. 4.00

E. None of these.

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13). A 25.0 kg chair is pushed across a frictionless horizontal floor with a force of 20.0 N, directed 20.0° below the horizontal. The acceleration of the chair is:

A. 0.27 m/s^2

B. 0.75 m/s^2

C. 0.90 m/s^2

D. 170 m/s^2

E. 470 m/s^2

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14). Water is drawn from a well in a bucket tied to the end of a rope whose other end wraps around a solid cylinder of mass 50 kg and diameter 25 cm. As you turn this cylinder with a crank, the rope raises the bucket. If the mass of a bucket of water is 20 kg, what torque must you apply to the crank to raise the bucket of water at a constant speed?

A. 24 N m

B. 2.5 N m

C. 80 N m

D. 2.4×10^3 N m

E. 49 N m

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15). The *complete* set of condition(s) necessary for static equilibrium is:

A. $\Sigma\vec{F}_i = 0$

B. $\Sigma\vec{\tau}_i = 0$

C. $\Sigma m\vec{r}_i = 0$

D. Both (a) and (b).

E. All of the above.

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16). Four objects, a ring, a disk, a solid sphere, and a hollow sphere, all have the same mass M and radius R. After rolling down an inclined plane without slipping, which has the greatest *total* kinetic energy?

A. The ring.

B. The disk.

C. The solid sphere.

D. The hollow sphere.

E. All have the same total kinetic energy.

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17). A spaceship lands on the moon with its rocket turned off. Let M be the mass of the moon, m be the mass of the spaceship, and R be the distance from the center of the moon. Considering only the gravitational field of the moon, the change in kinetic energy of the spaceship when moving from position R_1 to R_2 is:

A. GMm/R_2

B. GMm/R_2^2

C. $GMm(R_1 - R_2)/R_2^2$

D. $GMm(R_1 - R_2)/R_1R_2$

E. $GMm(R_1 - R_2)/(R_1R_2)^2$

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18). Particle A, with mass 3.0 kg, is located at the position $(2.0\ \text{m}, 0.0)$ with a velocity $\vec{v} = 0.0\hat{\imath} + 3.0\hat{\jmath}$ m/s. Particle B, with mass 6.0 kg, is located at the position $(0.0, 3.0\ \text{m})$ with velocity $\vec{v} = 3.0\hat{\imath} + 0.0\hat{\jmath}$ m/s. The magnitude of the total angular momentum (for both particles) with respect to the origin is:

A. 0 kg m^2/s

B. 6 kg m^2/s

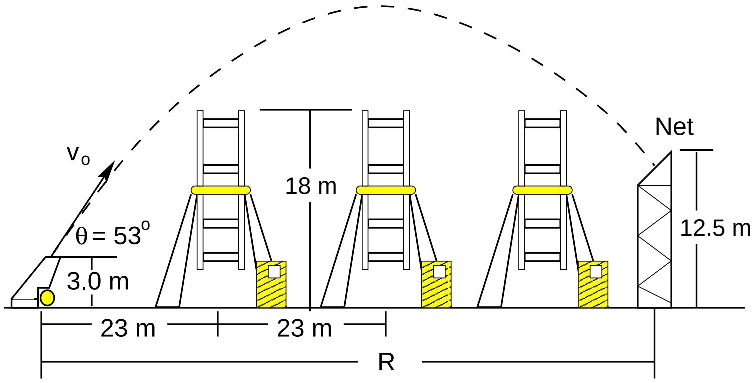
C. 9 kg m^2/s

D. 18 kg m^2/s

E. 36 kg m^2/s

Part B – **10 Point Questions**

19). The Great Proffini fired himself over three 18 m tall Ferris wheels as shown. Proffini was launched with speed $v_o = 26.5$ m/s at an angle of $\theta = 53.0°$ from the horizontal and with an initial height of 3.0 m above the ground. The net in which he lands is 12.5 m high at a range R from the cannon.



a). By what vertical distance does he pass above the first Ferris wheel?

b). How long (in seconds) has he been in the air when he lands at the net?

c). What is the range R of Proffini when he lands in the net?

All work and physical reasoning must be shown for credit!!

20). A two-engine jet is cruising along when one of the engines stops. The working engine then exerts a torque on the plane. We can approximate the plane by two perpendicular bars joined at their centers. The first bar (the fuselage) has length 25 m and mass 18000 kg. The second bar (the wings) has length 15 m and mass 2000 kg. Assume for simplicity that both bars have a uniform mass density.

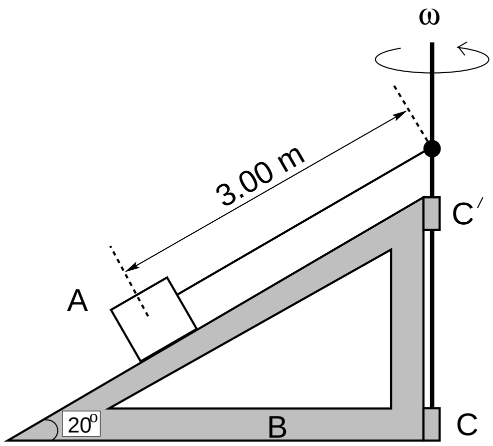
a). What is the rotational inertia (I) for the whole plane rotating about its center of mass?

b). The engine is located 2.5 m from the center of mass and pushes with a force of 8000 N. What is the torque about the center of mass?

c). What is the angular rotation (in degrees) of the plane in the 5 seconds before the pilot compensates? *Hint: What is the angular acceleration?*

All work and physical reasoning must be shown for credit!!

21). An object A, with mass 5.00 kg, rests on an inclined surface (frame B), which is revolved about a vertical axis C-C′ with a constant angular velocity ω. The object is attached to the axis C-C′ by a cord, as shown, and friction between object A and frame B can be neglected.



a). Draw a free-body diagram for object A.

b). With ω at a constant 20.0 revolutions per minute, what is the tension in the cord?

c). If ω is increased beyond some value, object A will lose contact with the frame B, and start to float above the frame. At what angular velocity ω will this just happen?

All work and physical reasoning must be shown for credit!!

22). A block of wood with a mass of 4.65 kg is resting on a horizontal surface when a bullet with a mass of 18 g, moving horizontally with a speed of 725 m/s, strikes it and remains embedded. The coefficient of kinetic friction between the block and the surface is $\mu_K = 0.35$.

a). How fast does the block + bullet move immediately after the collision?

b). For the block + bullet system, what is the difference in kinetic energy before and immediately after the collision?

c). What is the kinetic frictional force exerted on the block after the collision?

d). How far does the block travel after the collision before coming to rest?

All work and physical reasoning must be shown for credit!!

Equation List – P251 Final Exam

g = 9.81 m/s^2,   G = 6.67×10^{-11} N·m^2/kg^2

$v = v_0 + at, \quad \Delta x = v_0 t + \frac{1}{2}at^2, \quad v^2 = v_0^2 + 2a\Delta x, \quad \Delta x = \frac{1}{2}(v + v_0)t$

$\omega = \omega_0 + \alpha t, \quad \Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2, \quad \omega^2 = \omega_0^2 + 2\alpha\Delta\theta, \quad \Delta\theta = \frac{1}{2}(\omega + \omega_0)t$

$v = dx/dt, \quad a = dv/dt, \quad a_c = v^2/r, \quad s = r\theta, \quad v = \omega r, \quad a_t = \alpha r$

$\Sigma\vec{F}_{ext} = M\vec{a} = d\vec{p}/dt \qquad \Sigma\vec{\tau}_{ext} = I\vec{\alpha} = d\vec{L}/dt$

$\vec{\tau} = \vec{r}\times\vec{F} \qquad \vec{L} = \vec{r}\times\vec{p} = I\vec{\omega}$

$W = \int \vec{F}\cdot d\vec{r}, \qquad K = \frac{1}{2}MV^2$

F_{spr}=-kx, $\qquad U_{spr}=\frac{1}{2}kx^2, \qquad F_g = GM_1M_2/r^2, \qquad U_g =$ -GM_1M_2/r

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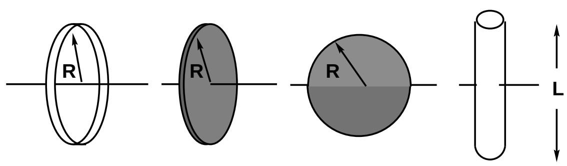
$M_{cm}\vec{r}_{cm} = \Sigma M_i\vec{r}_i, \qquad \vec{p}_{cm} = M\vec{v}_{cm}$

$\vec{a}\cdot\vec{b} = a_ib_i + a_jb_j + a_kb_k = |\vec{a}||\vec{b}|\cos\theta$

$\vec{a}\times\vec{b} = (a_jb_k - a_kb_j)\hat{i} - (a_ib_k - a_kb_i)\hat{j} + (a_ib_j - a_jb_i)\hat{k}$

Ring: $I = MR^2$; Solid disk: $I = \frac{1}{2}MR^2$; Solid sphere: $I = \frac{2}{5}MR^2$
Hollow sphere: $I = \frac{2}{3}MR^2$ Uniform bar: $I = \frac{1}{12}ML^2$



Parallel-axis theorem: $I = I_{cm} + MR^2$

$x = (-b \pm \sqrt{b^2 - 4ac})/2a$