Last Name:________________First Name _________________ID _________________

Discussion Section:________Discussion TA Name:__________________________

Instructions—
Please turn off your cell phone and put it away.
Calculators may not be shared. Please keep yours on your own desk.
This is a closed book exam. You have ninety (90) minutes to complete it.

1. Use a #2 pencil. Do not use a mechanical pencil or pen. Darken each circle completely, but stay within the boundary. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner. Be especially careful that your mark covers the center of its circle.

2. Print your **NETWORK ID** in the designated spaces at the right side of the answer sheet, starting in the left most column, then **mark the corresponding circle** below each character. If there is a letter "o" in your NetID, be sure to mark the "o" circle and not the circle for the digit zero. If and only if there is a hyphen "-" in your NetID, mark the hyphen circle at the bottom of the column. When you have finished marking the circles corresponding to your NetID, check particularly that you have not marked two circles in any one of the columns.

3. Print **YOUR LAST NAME** in the designated spaces at the left side of the answer sheet, then mark the corresponding circle below each letter. Do the same for your **FIRST NAME INITIAL**.

4. **You may find the version of this Exam Booklet at the top of the next page.** Mark the version circle in the TEST FORM box at the bottom right on your answer sheet. **DO THIS NOW!**

5. Print your UIN# in the **STUDENT NUMBER** designated spaces and mark the corresponding circles. You need not write in or mark the circles in the SECTION box

6. Sign your name (**DO NOT PRINT**) on the **STUDENT SIGNATURE** line.

7. On the **SECTION** line, print your **DISCUSSION SECTION**. You need not fill in the COURSE or INSTRUCTOR lines.

Before starting work, check to make sure that your test booklet is complete. In addition to these instructions, you should have 8 numbered pages plus one (1) Formula Sheet.

Academic Integrity: **Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including expulsion.**

This Exam Booklet is Version A. Mark the **A** circle in the TEST FORM box at the bottom right on your answer sheet. **DO THIS NOW!**

Exam Grading Policy—

The exam is worth a total of **111** points, composed of two types of questions.

MC5: *multiple-choice-five-answer questions, each worth 6 points.*
Partial credit will be granted as follows.

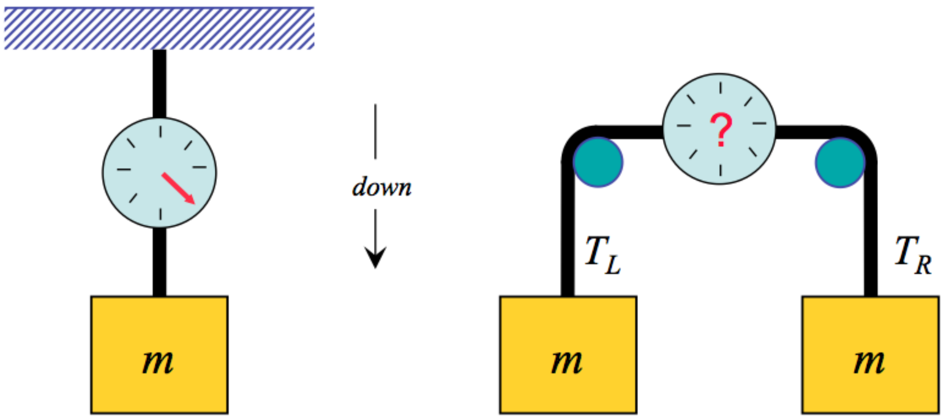
A) If you mark only one answer and it is the correct answer,
you earn **6** points.
B) If you mark two answers, one of which is the correct answer,
you earn **3** points.
C) If you mark three answers, one of which is the correct answer,
you earn **2** points.
D) If you mark no answers, or more than three, you earn 0 points.

MC3: *multiple-choice-three-answer questions, each worth 3 points*.
No partial credit.

A) If you mark only one answer and it is the correct answer,
you earn 3 points.
B) If you mark a wrong answer or no answers, you earn 0 points.

The next two questions pertain to the situation described below.

When a box of mass m is hung from a spring scale as shown on the left side of the figure, the reading of the spring scale tells us that the weight of the box is 80 N. A student now places the same spring scale between ropes that run over frictionless pulleys and support two identical boxes having the same mass m, as shown on the right side of the figure. Assume the spring-scale itself has no mass.



1) What is the tension in the rightmost rope in the figure on the right side, T_R?

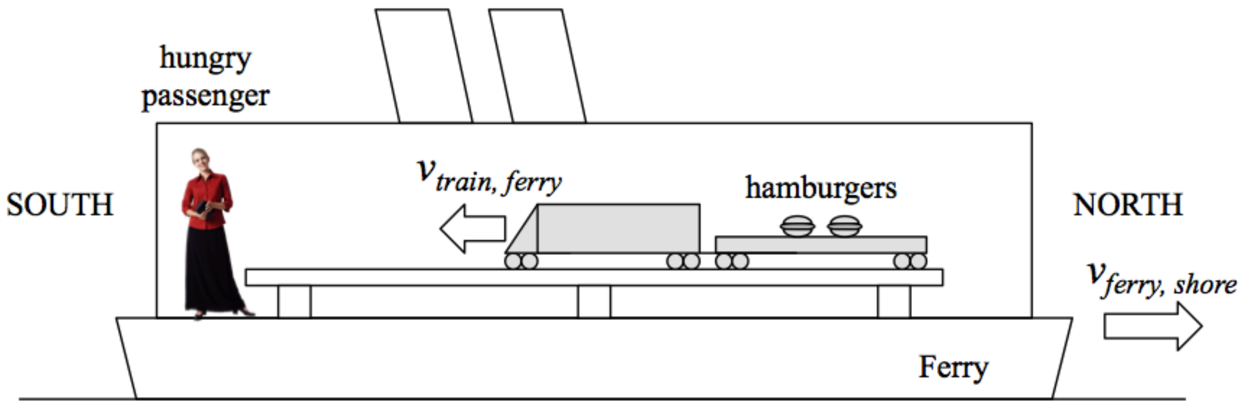
a. $T_R = 80$ N
b. $T_R = 40$ N
c. $T_R = 0$ N

2) What is the reading on the spring scale in the figure on the right side?

a. 160 N
b. 0 N
c. 80 N

The next two questions pertain to the situation described below.

An entrepreneur installs a toy train on a ferry boat to carry food from the ferry's kitchen to hungry passengers. The ferry travels through still water at 12 m/s. Assume that the water through which the ferry travels is stationary with respect to the shore. As the ferry travels north, the kitchen sends a plate of hamburgers to a passenger standing at the back, as shown in the picture. Assume that the toy train carrying the hamburgers travels 4 m/s with respect to the ferry.



3) What is the speed of the plate of hamburgers with respect to the passenger?

a. 12 m/s
b. 16 m/s
c. 0 m/s
d. 4 m/s
e. 8 m/s

4) What is the speed of the plate of hamburgers with respect to a stationary observer on land?

a. 8 m/s
b. 12 m/s
c. 4 m/s

The next three questions pertain to the situation described below.

An ice skater on a horizontal ice surface is moving along a circular path with a constant angular velocity of $\omega = 0.46$ radians per second. A tracking device indicates that her speed with respect to the ice is also constant and equals $v = 10$ m/s. The mass of the ice skater is $M = 80$ kg.

5) How long does it take for the skater to complete one full circle?

a. 13.66 s
b. 0.63 s
c. 6.83 s

6) What is the magnitude of the net force acting on the skater?

a. 785 N
b. 0 N
c. 4696 N
d. 368 N
e. 1153 N

7) What is the direction of the net force acting on the skater?

a. Inward, toward the center of the circular path.
b. Upward.
c. Both inward and upward.

The next three questions pertain to the situation described below.

Your friend is driving her car along a straight horizontal road. The mass of the car is $M = 1200$ kg and it has an initial velocity of $v_i = 45$ m/s. She slams on the brakes, locking the wheels so they don't spin, and skids to a stop leaving a black rubber skid-mark on the road. Suppose the car skids for exactly $t = 5.5$ seconds as it comes to rest, and that the coefficient of kinetic friction is constant during this time.

8) How long is the skid-mark on the road?

a. 62 m
b. 124 m
c. 247 m
d. 31 m
e. 1361 m

9) What is the coefficient of kinetic friction between the wheels of the car and the road?

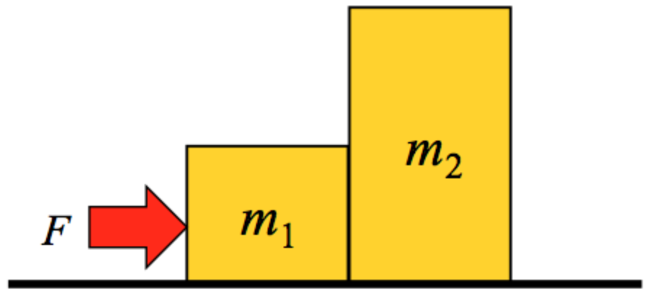
a. 0.22
b. 0.12
c. 0.56
d. 0.04
e. 0.83

10) Suppose the mass of the car was doubled but the initial speed of the car and the kinetic coefficient of friction was kept the same as in the original problem. How would the length of time that the car skids before stopping compare to the time taken in the original problem?

a. The amount of time needed to skid to a stop would quadruple.
b. The amount of time needed to skid to a stop would be the same.
c. The amount of time needed to skid to a stop would double.

The next three questions pertain to the situation described below.

A box of mass m_1 = 7 kg is in contact with a heavier box of mass m_2 = 12 kg. The boxes are initially at rest on a horizontal surface, and the coefficients of kinetic and static friction between the boxes and the surface are μ_K = 0.25 and μ_S= 0.41, respectively. A horizontal force F is applied to the left of m_1 as shown in the figure.



11) How large must F be to set the boxes in motion?

a. 46.6 N
b. 17.17 N
c. 0 N
d. 29.43 N
e. 76.42 N

12) When F = 114.63 N, what is the acceleration of the boxes?

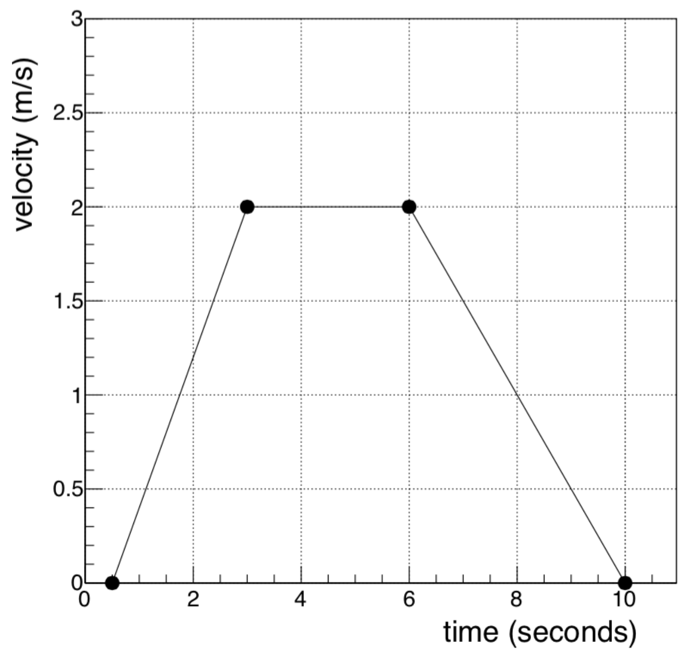
a. 16.38 m/s^2
b. 2.01 m/s^2
c. 3.58 m/s^2
d. 9.55 m/s^2
e. 6.03 m/s^2

13) When F = 114.63 N, what is F_{net2}/F_{net1}, the ratio of the net forces acting on m_2 and m_1?

a. $F_{net2}/F_{net1} = m_2/(m_1 + m_2)$
b. $F_{net2}/F_{net1} = m_1/m_2$
c. $F_{net2}/F_{net1} = m_2/m_1$

The next three questions pertain to the situation described below.

A box of mass m_1 = 7 kg moves along the x axis. A plot of its velocity versus time is shown in the figure to the right.



14) Which of the following statements is true?

a. The magnitude of the acceleration of the box is smaller at t = 2 seconds than at t = 8 seconds.
b. The magnitude of the acceleration of the box is larger at t = 2 seconds than at t = 8 seconds.
c. The magnitude of the acceleration of the box is the same at t = 2 seconds and at t = 8 seconds.

15) What is the displacement of the box between t = 6 seconds and t = 10 seconds?

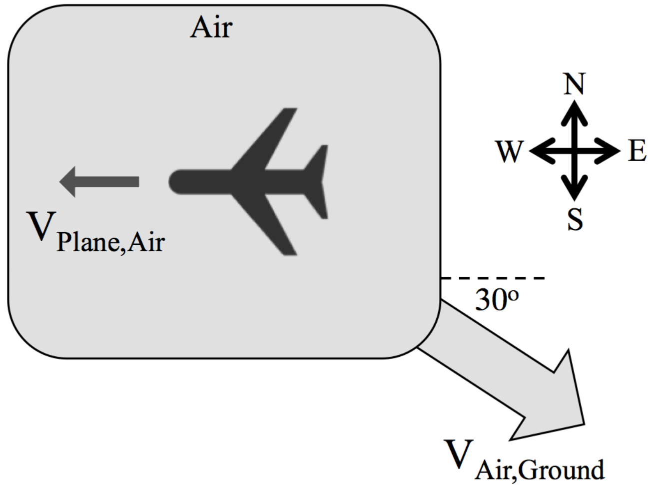
a. -8 m
b. 8 m
c. -4 m
d. 0 m
e. 4 m

16) What is the net force acting on the box at t = 8 seconds?

a. 1.8 N
b. 7 N
c. -3.5 N
d. -7 N
e. 3.5 N

The next three questions pertain to the situation described below.

A pilot points the nose of her airplane toward the west and flies with a speed $V_{Plane,Air} = 230$ m/s relative to the air. The air itself is moving with a speed $V_{Air,Ground} = 105$ m/s in a direction 30° South of East relative to the ground.



17) What is the magnitude of the velocity of the airplane relative to the ground?

a. 149 m/s
b. 139 m/s
c. 125 m/s
d. 335 m/s
e. 199 m/s

18) What is the direction of the velocity of the airplane relative to the ground?

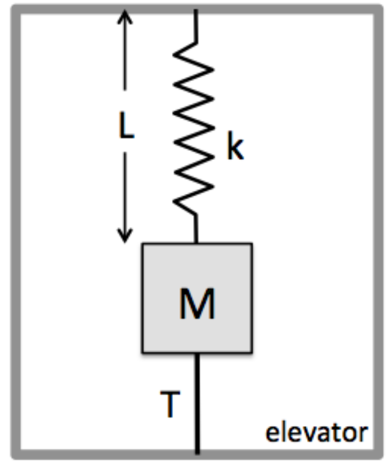
a. 69.3° South of West
b. 20.7° South of West
c. 69.3° South of East

19) Suppose the pilot wanted the velocity of her plane with respect to the ground to point directly toward the West. How many degrees North of West should she point the nose of her plane ?

a. Less than 30°
b. Exactly 30°
c. More than 30°

The next three questions pertain to the situation described below.

A box of mass $M = 3$ kg is suspended from the ceiling of an elevator by a spring, and is secured to the floor of the elevator by a string, as shown in the diagram. The spring has a constant of $k = 1300$ N/m and an unstretched length of $L_0 = 0.5$ m. The upward force provided by the spring is $F_S = 55.9$ N. The elevator is not moving.



20) Which of the following is the correct expression for the stretched length of the spring L?

a. $L = L_0 + F_S/k$
b. $L = (L_0 + F_S)/k$
c. $L = F_S/k$

21) What is the tension in the string T?

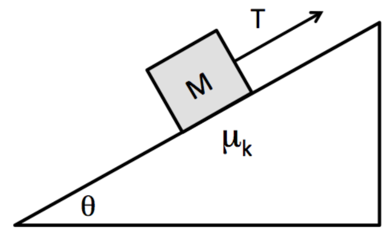
a. $T = 29.4$ N
b. $T = 0$ N
c. $T = 85.3$ N
d. $T = 26.5$ N
e. $T = 55.9$ N

22) Now suppose the elevator starts to accelerate downward. Which of the following best describes the new tension in the string compared to the tension you found above when the elevator was not moving?

a. The tension will be bigger when the elevator accelerates downward.
b. The tension will be smaller when the elevator accelerates downward.
c. The tension will be the same when the elevator accelerates downward.

The next three questions pertain to the situation described below.

A box of mass $M = 13$ kg is pulled up a ramp at a constant speed by a string that is parallel to ramp. The ramp makes an angle $\theta = 60°$ with the horizontal floor. The magnitude of the force of kinetic friction exerted by the ramp on the box is $f = 26.2$ N.



23) What is the coefficient of kinetic friction between the box and the ramp?

a. $\mu_K = 0.14$
b. $\mu_K = 0.21$
c. $\mu_K = 0.24$
d. $\mu_K = 0.41$
e. $\mu_K = 0.67$

24) What is the tension in the string?

a. $T = 26.2$ N
b. $T = 136.6$ N
c. $T = 22.7$ N
d. $T = 153.7$ N
e. $T = 90$ N

25) The net force acting on the box

a. is perpendicular to the surface of the ramp.
b. points up the ramp, parallel to the surface of the ramp.
c. is zero.

Phys 211 Formula Sheet

Kinematics

$\mathbf{v} = \mathbf{v}_0 + \mathbf{a}t$

$\mathbf{r} = \mathbf{r}_0 + \mathbf{v}_0 t + at^2/2$

$v^2 = v_0^2 + 2a(x-x_0)$

$g = 9.81\ m/s^2 = 32.2\ ft/s^2$

$\mathbf{v}_{A,B} = \mathbf{v}_{A,C} + \mathbf{v}_{C,B}$

Uniform Circular Motion

$a = v^2/r = \omega^2 r$

$v = \omega r$

$\omega = 2\pi/T = 2\pi f$

Dynamics

$\mathbf{F}_{net} = m\mathbf{a} = d\mathbf{p}/dt$

$\mathbf{F}_{A,B} = -\mathbf{F}_{B,A}$

$F = mg$ (near earth's surface)

$F_{12} = -Gm_1m_2/r^2$ (in general)

(where $G = 6.67\text{x}10^{-11}\ Nm^2/kg^2$)

$\mathbf{F}_{spring} = -k\,\mathbf{\Delta x}$

Friction

$f = \mu_k N$ (kinetic)

$f \leq \mu_S N$ (static)

Work & Kinetic energy

$W = \int \mathbf{F}\cdot\mathbf{dl}$

$W = \mathbf{F}\cdot\mathbf{\Delta r} = F\,\Delta r\,cos\theta$

(constant force)

$W_{grav} = -mg\Delta y$

$W_{spring} = -k(x_2^2 - x_1^2)/2$

$K = mv^2/2 = p^2/2m$

$W_{NET} = \Delta K$

Potential Energy

$U_{grav} = mgy$ (near earth surface)

$U_{grav} = -GMm/r$ (in general)

$U_{spring} = kx^2/2$

$\Delta E = \Delta K + \Delta U = W_{nc}$

Power

$P = dW/dt$

$P = \mathbf{F}\cdot\mathbf{v}$ (for constant force)

System of Particles

$\mathbf{R}_{CM} = \Sigma m_i\mathbf{r}_i / \Sigma m_i$

$\mathbf{V}_{CM} = \Sigma m_i\mathbf{v}_i / \Sigma m_i$

$\mathbf{A}_{CM} = \Sigma m_i\mathbf{a}_i / \Sigma m_i$

$\mathbf{P} = \Sigma m_i\mathbf{v}_i$

$\Sigma\mathbf{F}_{EXT} = M\mathbf{A}_{CM} = d\mathbf{P}/dt$

Impulse

$\mathbf{I} = \int \mathbf{F}\,dt$

$\Delta\mathbf{P} = \mathbf{F}_{av}\Delta t$

Collisions:

If $\Sigma\mathbf{F}_{EXT} = 0$ in some direction, then $\mathbf{P}_{before} = \mathbf{P}_{after}$ in this direction:

$\Sigma m_i\mathbf{v}_i$ (before) $= \Sigma m_i\mathbf{v}_i$ (after)

<u>In addition, if the collision is elastic:</u>

* $E_{before} = E_{after}$
* *Rate of approach = Rate of recession*
* *The speed of an object in the Center-of-Mass reference frame is unchanged by an elastic collision.*

Rotational kinematics

$s = R\theta,\ v = R\omega,\ a = R\alpha$

$$\left.\begin{aligned} &\theta = \theta_0 + \omega_0 t + {}^1\!/_2\alpha t^2 \\ &\omega = \omega_0 + \alpha t \\ &\omega^2 = \omega_0^2 + 2\alpha\Delta\theta \end{aligned}\right\}$$

Rotational Dynamics

$I = \Sigma m_i r_i^2$

$I_{parallel} = I_{CM} + MD^2$

$I_{disk} = I_{cylinder} = {}^1\!/_2 MR^2$

$I_{hoop} = MR^2$

$I_{solid\text{-}sphere} = {}^2\!/_5 MR^2$

$I_{spherical\ shell} = {}^2\!/_3 MR^2$

$I_{rod\text{-}cm} = {}^1\!/_{12} ML^2$

$I_{rod\text{-}end} = {}^1\!/_3 ML^2$

$\tau = I\alpha$ (rotation about a fixed axis)

$\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$, $|\tau| = rF\sin\phi$

Work & Energy

$K_{rotation} = {}^1\!/_2 I\omega^2$,

$K_{translation} = {}^1\!/_2 MV_{cm}^2$

$K_{total} = K_{rotation} + K_{translation}$

$W = \tau\theta$

Statics

$\Sigma\mathbf{F} = 0$, $\Sigma\tau = 0$ (about any axis)

Angular Momentum:

$\mathbf{L} = \mathbf{r} \times \mathbf{p}$

$L_z = I\omega_z$

$\mathbf{L}_{tot} = \mathbf{L}_{CM} + \mathbf{L}^*$

$\boldsymbol{\tau}_{ext} = d\mathbf{L}/dt$

$\boldsymbol{\tau}_{cm} = d\mathbf{L}^*/dt$

$\Omega_{precession} = \tau / L$

Simple Harmonic Motion:

$d^2x/dt^2 = -\omega^2 x$

(differential equation for SHM)

$x(t) = A\cos(\omega t + \phi)$

$v(t) = -\omega A\sin(\omega t + \phi)$

$a(t) = -\omega^2 A\cos(\omega t + \phi)$

$\omega^2 = k/m$ (mass on spring)

$\omega^2 = g/L$ (simple pendulum)

$\omega^2 = mgR_{CM}/I$ (physical pendulum)

$\omega^2 = \kappa/I$ (torsion pendulum)

General harmonic transverse waves:

$y(x,t) = A\cos(kx - \omega t)$

$k = 2\pi/\lambda,\quad \omega = 2\pi f = 2\pi/T$

$v = \lambda f = \omega/k$

Waves on a string:

$$v^2 = \frac{F}{\mu} = \frac{(\text{tension})}{(\text{mass per unit length})}$$

$$\bar{P} = \frac{1}{2}\mu v\omega^2 A^2$$

$$\frac{d\bar{E}}{dx} = \frac{1}{2}\mu\omega^2 A^2$$

$$\frac{d^2y}{dx^2} = \frac{1}{v^2}\frac{d^2y}{dt^2} \quad \text{Wave Equation}$$

Fluids:

$$\rho = \frac{m}{V} \qquad p = \frac{F}{A}$$

$$A_1v_1 = A_2v_2$$

$$p_1 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1 = p_2 + \tfrac{1}{2}\rho v_2^2 + \rho g y_2$$

$$F_B = \rho_{liquid} g V_{liquid}$$

$$F_2 = F_1\frac{A_2}{A_1}$$