Answer all questions, beginning each new question in the space provided. Show all work. Show all formulas used for each problem prior to substitution of numbers. Label diagrams and include appropriate units for your answers. Write your name and section number at the top of each page in the space provided and write the name of your section instructor in the place provided in the cover sheet. You may use an alphanumeric calculator (one which exhibits physical formulas) during the exam as long as you do not program any formulas into memory. By using an alphanumeric calculator you agree to allow us to check its memory during the exam. Simple scientific calculators are always OK!

Score on each problem:

1. (15) _____
2. (7) _____
3. (6) _____
4. (6) _____
5. (6) _____
6. (10) _____

Total Score (out of 50 pts) _____

Total Score (scaled up to 100 pts) _____

Be Prepared to Show your Student ID Card

A Formula Sheet Is Attached To The Back Of This Examination
For your convenience you may carefully remove it from the Exam. Please take it with you at the end of the exam or throw it in a waste basket. Thank you!
Problem 1: (15 points - 3 pts each – no partial credit – no need to show logic – in each question, put a circle around the letter that you think is the best answer.)

1-1. The position versus time of a car traveling in a straight line is shown. The car is:

(a) speeding up all the time
(b) slowing down all the time
(c) moving with constant speed
(d) speeding up part of the time and slowing down part of the time
(e) none of the above

![Graph of position versus time](image)

1-2. A vector of magnitude 10 is added to a vector of magnitude 15. The magnitude of the resultant vector CANNOT be:

(a) 10 (b) 25 (c) 5 (d) 15 (e) 4

1-3. A block of mass $m$ hangs from a string attached to the ceiling of an elevator that is moving downward and slowing down. The force due to gravity ($mg$) and the tension ($T$) in the string are related as:

(a) $T > mg$  (b) $T < mg$ (but not 0)  (c) $T = mg$  (d) $T = 0$  (e) none of the above

1-4. Which of the curves on the graph best represents the y-component of the velocity $v_y$ versus $t$ for a projectile fired at an angle of 45° above the horizontal?

![Graph of velocity versus time](image)

(a) A  (b) B  (c) C  (d) D  (e) E

1-5. A block of mass $m$ is pushed along a horizontal floor by an applied force $F$ that acts downwards at an angle $\theta$ from the horizontal as shown. The normal force exerted on the block by the floor is:

(a) $mg$  (b) $mg - F\cos\theta$  (c) $mg + F\cos\theta$  (d) $mg - F\sin\theta$  (e) $mg + F\sin\theta$
Problem 2: (7 points) A particle travels in a straight line along the x-axis. Its position, as a function of time, is given by \( x(t) = 4t^2 - 3t - 2 \), where \( x \) is given in meters and \( t \) in seconds. What is

(i) (2 pts) the distance traveled by the particle between \( t = 0 \) and \( t = 1 \) s?
(ii) (3 pts) the instantaneous velocity of the particle at \( t = 1 \) s?
(iii) (2 pts) the average velocity of the particle between \( t = 0 \) and \( t = 1 \) s?
Problem 3: (6 points)
The graph represents the straight-line motion of a car.

(i) (3 pts) Plot the acceleration of the car from $t = 0$ to $t = 9$ s?
(ii) (3 pts) What distance does the car traverse between $t = 0$ s and $t = 9$ s?
Problem 4: (6 points) A stone is thrown *horizontally* in the positive x-direction from the top of a 25-m high building with a speed of 15 m/s.
(i) (3 pts) What is the y-velocity of the stone when it hits the ground?
(ii) (3 pts) At the instant it hits the ground, express the instantaneous velocity vector of the stone in the standard $\hat{i},\hat{j}$ format. (Use upwards as the positive y-direction.)
Problem 5: (6 points) Two blocks (X and Y) are in contact on a horizontal frictionless surface. A constant force $F$ is applied to X as shown. The common acceleration of the two objects is $1.5 \text{ m/s}^2$. Find

(i) (3 pts) the force $F$

(ii) (3 pts) the force exerted by Y on X?

$m_X = 4 \text{ kg}$

$m_Y = 20 \text{ kg}$
Problem 6: (10 points) In the system shown, two objects A and B, with masses $m_A = 15$ kg and $m_B = 11$ kg are connected by a string that passes over a massless pulley. There is no friction anywhere. A force $F$ moves the objects at constant velocity up the slopes.

(i) (4 pts) Draw free-body diagrams denoting all the forces acting on the two objects.
(ii) (3 pts) Focusing first on object A, find the tension in the string.
(iii) (3 pts) Focusing next on object B, and using the result from part (ii), find the force $F$. 

![Diagram of the system with angles and forces labeled]
95.141 Fall 2012 Formulae

Trig:
\[ \sin \theta = \frac{a}{c} \]
\[ \cos \theta = \frac{b}{c} \]
\[ \tan \theta = \frac{a}{b} \]
\[ c^2 = a^2 + b^2 \]

Quadratic Formula:
\[ Ax^2 + Bx + C = 0 \] has solutions:
\[ x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A} \]

Misc Formulas:
Circumference of a circle = 2πR
Area of a circle = πR²
Surface Area of a Sphere = 4πR²
Volume of sphere = \( \frac{4}{3} \pi R^3 \)
Volume of cylinder = πR²L

Differentiation:
\[ \frac{dx^n}{dx} = nx^{n-1} \] (n \( \neq 0 \))
\[ \frac{d\cos(x)}{dx} = -\sin(x) \] (x in radians)
\[ \frac{d\sin(x)}{dx} = \cos(x) \] (x in radians)
\[ \frac{d(f(x) + g(x))}{dx} = \frac{df(x)}{dx} + \frac{dg(x)}{dx} \]

Integration:
\[ \int x^n \, dx = \frac{x^{n+1}}{n+1} + C \]

1-D Motion:
displacement = Δx
\[ v_{\text{average}} = \frac{\Delta x}{\Delta t} = \frac{(x_2 - x_1)}{(t_2 - t_1)} \]
\[ a_{\text{average}} = \frac{\Delta v}{\Delta t} = \frac{(v_2 - v_1)}{(t_2 - t_1)} \]

Given \( x(t) \)
\[ v(t) = \frac{dx}{dt} \] (instantaneous)
\[ a(t) = \frac{dv}{dt} = \frac{d^2x}{dt^2} \]
(instantaneous)

1-D Motion with Const. Acc.:
\[ x(t) = x_0 + v_0 t + \frac{1}{2} a t^2 \]
\[ v(t) = v_0 + at \]
\[ v^2 = v_0^2 + 2a(x - x_0) \]

Projectile Motion:
\[ x(t) = x_0 + v_{0x} t \]
\[ y(t) = y_0 + v_{0y} t + \frac{1}{2} a_y t^2 \]
\[ v_x(t) = v_{0x} + a_x t \]
\[ a_x(t) = a_y \]

For motion over level ground
Range = \( \frac{v_0^2 \sin(2\theta)}{g} \)

Acceleration due to gravity:
g = 9.8 m/s² downward

Newton's Second Law:
\[ \vec{F}_{\text{net}} = \sum \vec{F}_{\text{ext}} = m \vec{a} \]