Physics 1303(001),1403(801) **Professor Scalise**
Spring 1996 **Midterm #1**

Name: _____ ID number:_____

This exam is worth 100 points. It consists of 15 multiple-choice questions worth 5 points each and a partial credit section worth a maximum of 25 points.

Don't get hung up on the questions. They should only take a few minutes each. If you find yourself spending more than a few minutes on a question you are probably looking at it the wrong way. You should skip it temporarily and return to it later.

NOTE - The equation sheets are on the last page. If you think that it makes referring to them easier, you can remove them from the rest of the exam.

GOOD LUCK

1. Three vectors sum to zero. Their magnitudes **cannot** be

   (a) 2,4,5

   (b) 3,7,9

   (c) 2,6,9

   (d) 3,6,6

   (e) 3,3,3

2. The speed of a particle in kilometers/hour is given by $v(t) = 17t^3 + 4t$, with t measured in hours. What are the (hidden) units of the coefficient 17?

   (a) km/(hr^4)

   (b) km/(hr^2)

   (c) 1/(hr^3)

   (d) km/hr

   (e) 1

3. What is the polar angle of the sum of the two vectors (4 m, 60°) and (2 m, 180°)?

   (a) 36°
   (b) 240°
   (c) 90°
   (d) 210°
   (e) 0°

4. Vector $\vec{B}$, when added to the vector $\vec{C} = 3\hat{\boldsymbol{i}} + 4\hat{\boldsymbol{j}}$, yields a resultant vector which is in the positive y direction and has a magnitude equal to that of $\vec{C}$. What is the vector $\vec{B}$?

   (a) (-1,-3)
   (b) (3,1)
   (c) (3,-1)
   (d) (-3,1)
   (e) (-1,3)

5. A stone is tossed straight up into the air. At its highest point, the stone has

   (a) downward velocity and downward acceleration

   (b) zero velocity and zero acceleration

   (c) zero velocity and downward acceleration

   (d) upward velocity and downward acceleration

   (e) upward velocity and zero acceleration

6. Of the following situations, which one is impossible?

   (a) a body having zero instantaneous velocity and non-zero instantaneous acceleration

   (b) a body having constant velocity and variable acceleration

   (c) a body having instantaneous velocity east and constant acceleration west

   (d) a body having constant acceleration and variable velocity

   (e) a body having instantaneous velocity east and constant acceleration north

7. A track star in the broad jump goes into the jump at 12 m/s and launches himself at 20° above the horizontal. How long is he in the air before returning to Earth? (Be sure that you solve for the **whole** time.)

   (a) 1.2 s

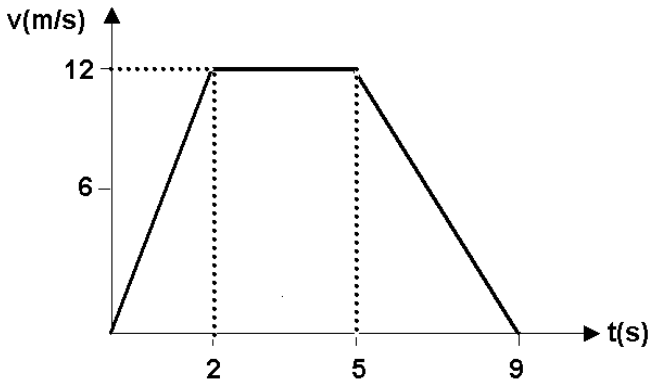
   (b) 1.0 s

   (c) 0.42 s

   (d) 2.3 s

   (e) 0.84 s

8. The graph below represents the one-dimensional motion of a car. What is the average acceleration between 2 s and 9 s?



   (a) -1.3 m/s^2

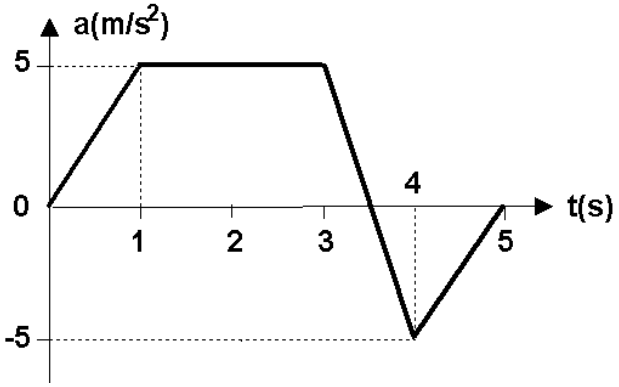
   (b) -3.0 m/s^2

   (c) -1.7 m/s^2

   (d) 1.3 m/s^2

   (e) 60 m/s^2

9. What is the change in velocity from $t = 0$ s to $t = 5$ s?



(a) 17.5 m/s

(b) 5.0 m/s

(c) 10.0 m/s

(d) 25.0 m/s

(e) 20.0 m/s

10. A bomber flying in level flight at some height above the Earth, close to the surface, must release its bomb before it is over the target. Neglecting air resistance, which one of the following is **NOT** true?

(a) the time of flight of the bomb is independent of the horizontal speed of the plane

(b) the bomber will be over the target when the bomb strikes

(c) the acceleration of the bomb is constant

(d) the bomb travels in a parabolic path

(e) the magnitude of the bomb's vector velocity just before it strikes the ground is the same as when it left the plane

11. The velocity of a particle moving in a straight line is given by $v(t) = 3t^2 + 4t - 2$, where v is measured in meters/second and t is given in seconds. What is the change in the particle's displacement from $t = 1$ s to $t = 2$ s?

(a) 15 m

(b) 13 m

(c) 6 m

(d) 25 m

(e) 11 m

12. A car travels in a horizontal circle of radius r. At a certain instant the velocity of the car is 24 m/s west, and the total acceleration of the car is 2.5 m/s^2 53° north of west. Which of the following is correct?

(a) r = 0.23 km, and the car's speed is increasing.

(b) r = 0.29 km, and the car's speed is constant.

(c) r = 0.29 km, and the car's speed is decreasing.

(d) r = 0.23 km, and the car's speed is decreasing.

(e) r = 0.29 km, and the car's speed is increasing.

13. Two balls are thrown from the top of a building 100 m high. One ball is thrown straight up at 4 m/s while the other is thrown straight down at 4 m/s. Which statement is true?

(a) both balls take 4.94 s to hit the ground

(b) both balls hit the ground with speed 44.5 m/s

(c) both balls hit the ground with speed 44.0 m/s

(d) the balls take different amounts of time to hit the ground and they hit with different speeds.

(e) both balls take 4.13 s to hit the ground

14. A stone is kicked off the top of a cliff 80 m high with an initial velocity of 20 m/s in the **horizontal** direction. How far from the base of the cliff will the stone land?

(a) 130 m

(b) 80 m

(c) 50 m

(d) 90 m

(e) 20 m

15. Fill in the five blanks from the choices listed below.

(a) The slope of the line connecting two points on a velocity vs. time plot is the _____.

(b) The area under the curve on an acceleration vs. time plot from time t_1 to time t_2 is the _____ from time t_1 to time t_2.

(c) The area under the curve on a velocity vs. time plot from time t_1 to time t_2 is the _____ from time t_1 to time t_2.

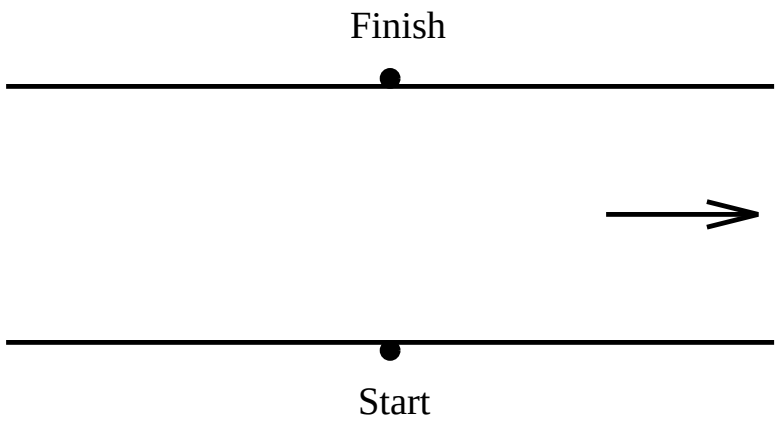
(d) The slope of the line connecting two points on a position vs. time plot is the _____.

(e) The slope of the line tangent to the curve at a single point on a position vs. time plot is the _____.

change in displacement	average displacement	instantaneous displacement
change in velocity	average velocity	instantaneous velocity
change in acceleration	average acceleration	instantaneous acceleration

Partial Credit Section (25 points)

A 200-m wide river has a uniform flow speed of 3.0 m/s toward the east. A boat with a speed of 8.0 m/s relative to the water leaves the south bank and heads in such a way that it crosses to a point directly north of its departure point.



How long does it take the boat to cross the river?

How far has the boat traveled?

What is the speed of the boat relative to the shore?

What angle does the boat's heading (where the bow points) make with the shore?

Can the boat travel from any point on the south shore to any point on the north shore in less time? If so, what is the minimum time?

How far would the boat travel?

What is the speed of the boat relative to the shore?

What angle does the boat's heading (where the bow points) make with the shore?

USEFUL FORMULÆ AND CONSTANTS

Average velocity and acceleration

$$\vec{\bar{v}} = \frac{\Delta \vec{r}}{\Delta t} \qquad\qquad \vec{\bar{a}} = \frac{\Delta \vec{v}}{\Delta t}$$

Instantaneous velocity and acceleration

$$\vec{v} = \frac{d\vec{r}}{dt} \qquad\qquad \vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2}$$

Equations for motion with a constant acceleration

$$\vec{v}(t) = \vec{v}_0 + \vec{a}t$$

$$\vec{r}(t) - \vec{r}_0 = \vec{v}_0 t + \tfrac{1}{2}\vec{a}t^2$$

$$\vec{r}(t) - \vec{r}_0 = \tfrac{1}{2}[\vec{v}_0 + \vec{v}(t)]t$$

$$[\vec{v}(t)]^2 = \vec{v}_0^{\,2} + 2\vec{a} \cdot [\vec{r}(t) - \vec{r}_0]$$

Relative Velocity

$$\vec{v}_{ac} = \vec{v}_{ab} + \vec{v}_{bc} \qquad\qquad \vec{v}_{ab} = -\vec{v}_{ba}$$

Radial Acceleration

$$a_r = \frac{v^2}{r}$$

Tangential Acceleration

$$a_t = \frac{d|\vec{v}|}{dt}$$

Newton's Second Law $\vec{F} = m\vec{a}$

Derivative and integrals of power functions

$$\frac{d}{dx}\left(Ax^n\right) = nAx^{n-1} \qquad\qquad \int Bx^n\, dx = \frac{B}{n+1}x^{n+1} + constant$$

Quadratic equation

$$ax^2 + bx + c = 0 \implies x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Physical Constants

Acceleration due to gravity (g)	9.80 m/s^2 = 32 ft/s^2
Average earth-moon distance	3.84 x 10^8 m
Average earth-sun distance	1.49 x 10^{11} m
Average radius of the earth	6.37 x 10^6 m
Mass of the earth	5.98 x 10^{24} kg
Mass of the moon	7.36 x 10^{22} kg
Mass of the sun	1.99 x 10^{30} kg
Gravitational constant (G)	6.672 x 10^{-11} $N \cdot m^2/kg^2$

Conversion Constants

Length

1 in. = 2.54 cm
1 m = 39.37 in. = 3.281 ft
1 ft = 0.3048 m
12 in. = 1 ft
3 ft = 1 yd
1 yd = 0.9144 m
1 km = 0.621 mi
1 mi = 1.609 km
1 Å= 10^{-10} m
1 mm = 10^{-3} m
1 μm = 10^{-6} m = 10^4 Å
1 lightyear = 9.461 x 10^{15} m

Mass

1000 kg = 1 t (metric ton)
1000 g = 1 kg
1 slug = 14.59 kg
1 u = 1.66 x 10^{-27} kg

Energy

1 J = 0.738 ft·lb = 10^7 erg
1 cal = 4.186 J
1 Btu = 252 cal = 1.054 x 10^3 J
1 eV = 1.6 x 10^{-19} J
931.5 MeV = 1 u
1 kW·h = 3.6 x 10^6 J

Improper Conversions

1 lb (weight) = 0.454 kg (mass) at the surface of the earth

Force

1 N = 10^5 dyne = 0.2248 lb
1 lb = 4.448 N
1 dyne = 10^{-5} N = 2.248 x 10^{-6} lb

Velocity

1 mi/h = 1.47 ft/s = 0.447 m/s
1 mi/h = 1.61 km/h
1 m/s = 100 cm/s = 3.281 ft/s
1 mi/min = 60 mi/h = 88 ft/s

Acceleration

1 m/s^2 = 3.28 ft/s^2 = 100 cm/s^2
1 ft/s^2 = 0.3048 m/s^2 = 30.48 cm/s^2

Power

1 hp = 550 ft·lb/s = 0.746kW
1 W = 1 J/s = 0.738 ft·lb/s
1 Btu/h = 0.293 W