University Physics 1
Midterm Exam 1

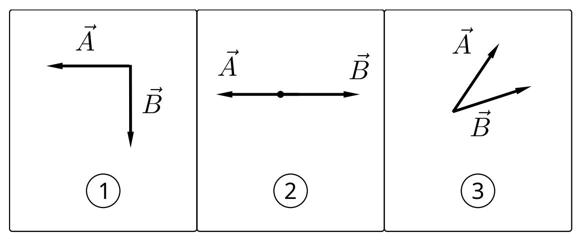
Name: ______________________________

Multiple Choice Questions:
Select the best answer by circling the letter.

1. Which of the following could be units of acceleration?

a. mi/hr b. $mi^2/hr/s$
c. mi/hr/s d. mi^2/hr^2

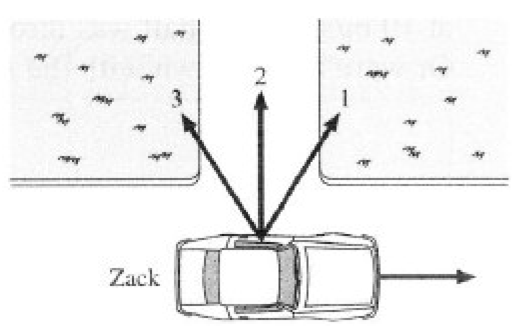
2. Consider the three pairs of vectors shown at the right. Which of the following gives the correct sign (+ , – , or 0) of the dot product ($\vec{A} \cdot \vec{B}$) for each pair?



a. 1:+ , 2: – , 3: 0 b. 1:+ , 2:0 , 3:–

c. 1:0 , 2:– , 3:+ d. 1:0 , 2:0 , 3:–

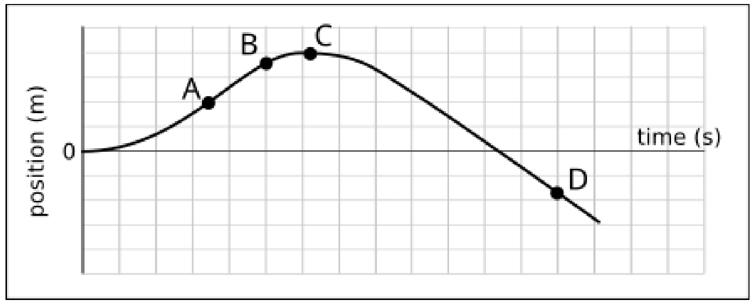
3. Zack is driving past his house. He wants to toss a book out of the window and have it land in his driveway. If he lets go of the book exactly as he passes the end of the driveway, in what direction should he throw the book?



a. 1 b. 2 c. 3

d. it cannot be done

4. The figure shows a position-versus-time graph for a moving object. At which of the lettered points is the object slowing down?



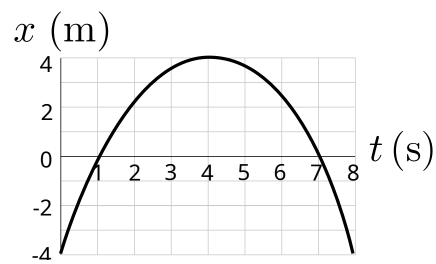
a. A

b. B

c. C

d. D

5. For the motion shown at the right, what is the approximate instantaneous velocity at time $t = 7$ s ?



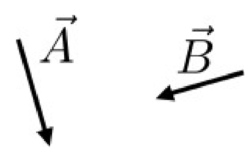
a. 0 m/s

b. 3 m/s

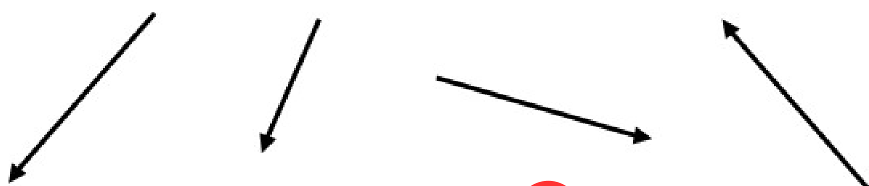
c. -3 m/s

d. 4 m/s

6. Vectors $\vec{A}$ and $\vec{B}$ are shown at the right.



Which vector below shows the result of $\vec{A} - 2\vec{B}$?



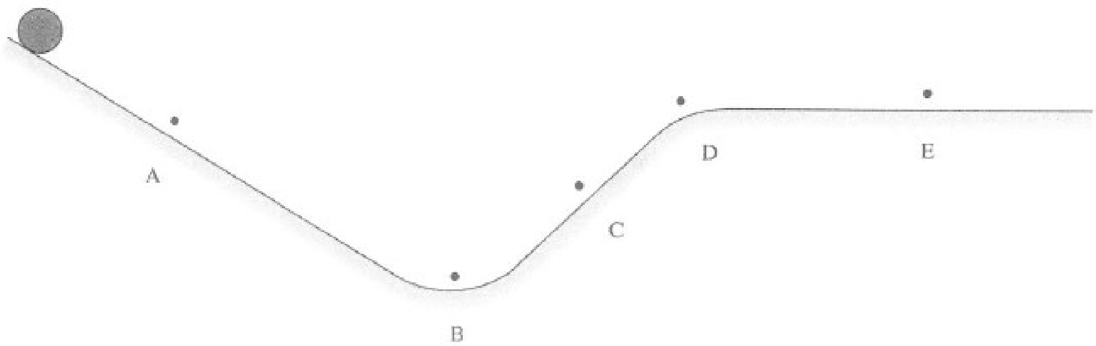
a.

b.

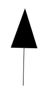
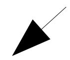
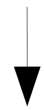
c.

d.

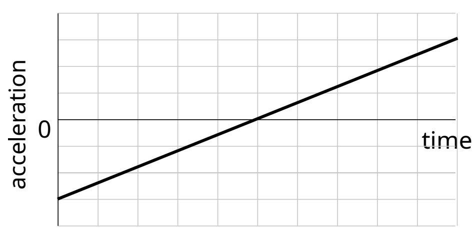
7. The figure below shows a ramp and a ball that rolls along the ramp.

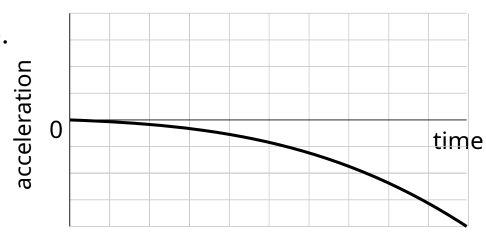


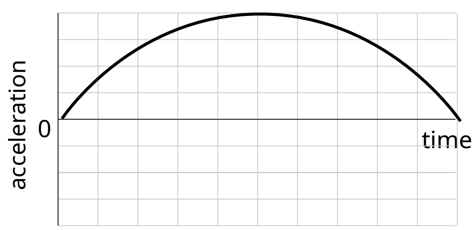
What is the direction of the ball's acceleration vector as it passes point B?

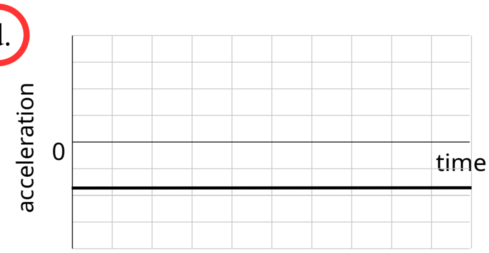
a.  b.  c.  d. 

8. Which of the following graphs of acceleration could represent free-fall motion?

a.


b.


c.


d.


Long Answer Problems:

Correct units must be included with every answer.

Answers should be written on the blank provided, and work that you want credit for must be done in the box. If you need more space, note that the work is continued on another page.

1. Answer the following questions about units and dimensions.
   a. The density of water is about 1000 kg/m^3. Given that 1 mL is equal in volume to 1 cm^3, what is the density of water in megagrams per microliter (that is, Mg/μL)?
   b. Suppose quantity a is an acceleration, ω is an angular velocity, and t is a time. Give the dimension of the following (use dimension symbols M, L, T for mass, length and time; use "1" for dimensionless quantities).
   i. $\int \omega\, dt$ ii. $\frac{da}{dt}$ iii. $\int a\, dt$

answers: a. 10^{-9} Mg/μL

b. i. 1

ii. L/T^3

iii. L/T

a. $$\rho = 1000 \frac{kg}{m^3}\cdot\left(\frac{1\ m}{100\ cm}\right)^3\cdot\frac{1\ cm^3}{1\ mL}\cdot\frac{10^3\ g}{1\ kg}\cdot\frac{1\ Mg}{10^6\ g}\cdot\frac{1\ mL}{10^3\ \mu L}$$

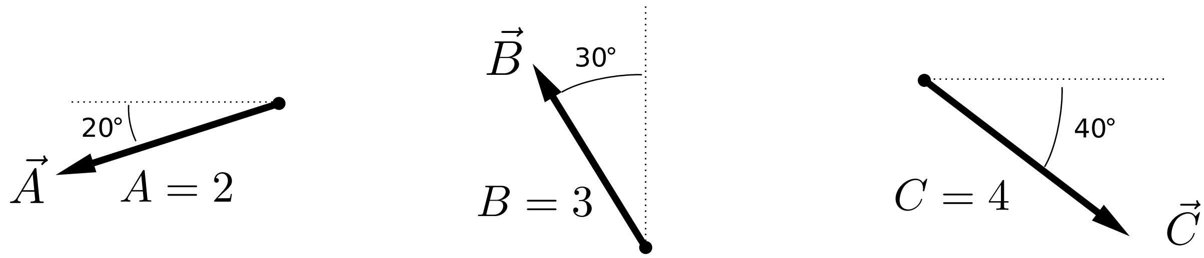
$$= 10^{3-6+3-6-3}\ \frac{Mg}{\mu L} = 10^{-9}\ \frac{Mg}{\mu L}$$

b. i. $\frac{1}{T}\cdot T = 1$

ii. $\frac{L/T^2}{T} = \frac{L}{T^3}$

iii. $\frac{L}{T^2}\cdot T = \frac{L}{T}$

2. Consider the following vectors. Assume the +*x*-axis is horizontal to the right.



Compute the following:

a. The component of vector $\vec{A}$ along vector $\vec{C}$.
b. The component of vector $\hat{\jmath}$ along vector $\vec{B}$.
c. $(\vec{A} - 3\vec{C}) \times \vec{B}$
d. $\vec{A} \cdot (\vec{B} \times \vec{C})$

answers: a. -1

b. 0.866

c. $-18.2\,\hat{k}$

d. 0

a. $\hat{u}_c = \hat{\imath}\cos 40° - \hat{\jmath}\sin 40$, $\vec{A} = 2(-\hat{\imath}\cos 20° - \hat{\jmath}\sin 20°)$

$\vec{A} \cdot \hat{u}_c = -2\cos 40° \cdot \cos 20° + 2\sin 40° \sin 20°$

$= -1.44 + 0.44 = -1$

b. $\hat{\jmath} \cdot \hat{u}_B = \cos 30° = 0.866$

c. $\vec{R} = \vec{A} - 3\vec{C} = (-2\cos 20° - 12\cos 40°)\hat{\imath} + (2\sin 20° + 12\sin 40°)$

$= -11.07\,\hat{\imath} + 7.03\,\hat{\jmath}$

$\vec{B} = -1.5\,\hat{\imath} + 2.60\,\hat{\jmath}$

$\vec{R} \times \vec{B} = \hat{k}(-28.78 + 10.545) = -18.2\,\hat{k}$

d. $\vec{A}$ is $\perp$ to $\vec{B} \times \vec{C}$

3. A hot-air balloon is at a height of 700 m at time $t = 0$. It descends toward the ground at a constant speed of 10.0 m/s. One minute after time zero, a sandbag is dropped from the balloon and falls straight down without significant air resistance. Calculate (a) the time it takes (after drop) for the sandbag to reach the ground and (b) the speed of the sandbag when it hits the ground.

answers:

time = 3.61 s

speed = 45.4 m/s

$v_0 = -10$ m/s

$y_0 = y(t=0) = 700 - 10(60) = 100$ m

$v_f^2 = v_i^2 + 2a\Delta s = (-10)^2 + 2(-9.8)(-100)$

$\rightarrow v_f = -45.39$ m/s

$v_f = v_0 - gt = -10 - 9.8t$

$\rightarrow t = 3.61$ s

4. A passenger is seated in a train moving with velocity $5\hat{\imath} + 5\hat{\jmath}$ m/s. While moving, she observes a balloon floating upward with a velocity relative to the train of $-3\hat{\imath} - 5\hat{\jmath} + 3\hat{k}$ m/s. What is the velocity of the balloon relative to an observer standing on the ground?
(Give your answer in $\hat{\imath}\,\hat{\jmath}\,\hat{k}$ notation.)

answer: $\vec{v} =$ $(2\hat{\imath} + 3\hat{k})$ m/s

Passenger, Balloon, Ground

$\vec{v}_{PG} = 5\hat{\imath} + 5\hat{\jmath}$ m/s

$\vec{v}_{BP} = -3\hat{\imath} - 5\hat{\jmath} + 3\hat{k}$ m/s

$\vec{v}_{BG} = \vec{v}_{BP} + \vec{v}_{PG} = 2\hat{\imath} + 3\hat{k}$ m/s

5. At time $t = 0$ s, the Lunar Excursion Module (LEM) is moving through space with velocity $\vec{v} = 300\hat{\imath}$ m/s. At this time is begins an acceleration of $\vec{a} = (-5t)\hat{\jmath} + 2\hat{k}$ m/s². After 3.0 s of this acceleration, find...
a. the LEM's velocity velocity vector.
b. it's displacement (relative to where it was at time $t = 0$).
(Give your answers in $\hat{\imath}\,\hat{\jmath}\,\hat{k}$ notation.)

answers: $\vec{v} = \left(300\,\hat{\imath} - 22.5\,\hat{\jmath} + 6\,\hat{k}\right)$ m/s

$\Delta\vec{s} = \left(900\,\hat{\imath} - 22.5\,\hat{\jmath} + 9\,\hat{k}\right)$ m

$$\vec{a} = -5t\,\hat{\jmath} + 2\,\hat{k}$$

$$\vec{v} = \vec{v}_0 + \int_0^t \vec{a}\,dt = \vec{v}_0 - \tfrac{5}{2}t^2\,\hat{\jmath} + 2t\,\hat{k}$$

$$\Delta\vec{s} = \int_0^t \vec{v}\,dt = \vec{v}_0 t - \tfrac{5}{6}t^3\,\hat{\jmath} + t^2\,\hat{k}$$

At time $t = 3$:

$$\vec{v} = \left(300\,\hat{\imath} - 22.5\,\hat{\jmath} + 6\,\hat{k}\right)\ \text{m/s}$$

$$\Delta\vec{s} = \left(900\,\hat{\imath} - 22.5\,\hat{\jmath} + 9\,\hat{k}\right)\ \text{m}$$