1. A particle starts out at the origin with a velocity given by $16\,\hat{\mathbf{\imath}} - 12\,\hat{\mathbf{\jmath}}$ (in m/s) and has an acceleration given by $3\,\hat{\mathbf{\imath}} - 6\,\hat{\mathbf{\jmath}}$ (in m/s^2). What is the speed of the particle at $t = 2$ seconds (answer in m/s)?

a) 52 b) 39 c) 46 d)* 33 e) none of these

$$\vec{v}(t) = \vec{v}_0 + \vec{a}t = 16\,\hat{\mathbf{\imath}} - 12\,\hat{\mathbf{\jmath}} + (3\,\hat{\mathbf{\imath}} - 6\,\hat{\mathbf{\jmath}})t$$

Substitute $t = 2$ seconds and compute the x and the y components of $\mathbf{v}$, and then the magnitude. You will find that $\vec{v}(t = 2) = 22\,\hat{\mathbf{\imath}} - 24\,\hat{\mathbf{\jmath}}$.

2. In the lecture demonstration called "shoot–the–monkey", it was best to aim the projectile

a) above the target b)* in the center of the target c) below the target
d) didn't matter, the projectile missed both times
e) none of these

The projectile will hit the target in the center, no matter what the speed of the projectile, as long as the projectile is aimed at the center, and has sufficient speed to reach the monkey.

3. At all times the net force on an object

a) is in the direction of the motion b) is opposite to the direction of motion
c) is at right angles to the motion d)* is in the direction of the acceleration e) none of these

Directly from Newton's Second Law in vector form

$$\vec{F} = m\vec{a}$$

4. At which point on the accompanying speed-time $v(t)$ graph is the instantaneous acceleration negative

a) point A b) point B c) point C d) point D e)* point E

This is the only line segment where the slope is negative.

5. A ball is thrown vertically upward from the Earth's surface and then falls back to Earth. Ignoring air resistance, which of the following graphs plots speed vs time correctly (speed is a magnitude, and is always positive)

Answer is a. The ball starts out with a speed, goes to zero speed linearly at the top of the motion, and then regains its speed in the opposite direction as it falls back to Earth.

6. If a vector $\vec{B}$ is added to a vector $\vec{A}$, the result is $6\,\hat{\mathbf{i}} + \hat{\mathbf{j}}$. If the vector $\vec{B}$ is subtracted from $\vec{A}$, the result is $-4\,\hat{\mathbf{i}} + 7\,\hat{\mathbf{j}}$. What is the *magnitude* of $\vec{A}$?

a) 5.1 b)* 4.1 c) 5.4 d) 5.8 e) 8.2

Do the math, using $\vec{B} = b_x\,\hat{\mathbf{i}} + b_y\,\hat{\mathbf{j}}$ and $\vec{A} = a_x\,\hat{\mathbf{i}} + a_y\,\hat{\mathbf{j}}$.

$$\vec{B} + \vec{A} = (a_x + b_x)\,\hat{\mathbf{i}} + (a_y + b_y)\,\hat{\mathbf{j}} = 6\,\hat{\mathbf{i}} + \hat{\mathbf{j}}$$
$$\vec{A} - \vec{B} = (a_x - b_x)\,\hat{\mathbf{i}} + (a_y - b_y)\,\hat{\mathbf{j}} = -4\,\hat{\mathbf{i}} + 7\,\hat{\mathbf{j}}$$

Add these two equations to get

$$2a_x + 2a_y = 2\,\hat{\mathbf{i}} + 8\,\hat{\mathbf{k}} \Longrightarrow a_x = 1 \quad a_y = 4$$

From this result you can get the magnitude $A = \sqrt{17} = 4.1$.

7. Assuming that L has dimensions of length, and g is the gravity acceleration, which of the following formulas could be a valid expression for the time T it takes a pendulum to complete one swing back and forth

a) $T = 2\pi L/g$ b)* $T = 2\pi\sqrt{L/g}$ c) $T = 2\pi\sqrt{g/L}$ d) $T = 2\pi g/L$ e) none of these is possible

The answer b) is the only one with the dimensions of time on the right hand side.

8. A person is driving a car on a flat road in a horizontal circle at constant speed. What can be said about the acceleration vector of the car?

a) it is zero b)* its magnitude is constant c) its direction is down
d) its value is 9.8 m/s^2 e) its direction is constant

The centripetal acceleration vector points to the center, meaning that the direction is changing continuously. However the magnitude is constant $a_c = v^2/r$ since the speed and the radius are constant.

9. What is the maximum height in meters for a projectile fired on the Moon's surface with initial velocity components $v_{x0} = 3.0$ m/s and $v_{y0} = 4.0$ m/s, given that the gravity acceleration on the moon has a value 1.6 m/s^2

a) 0.50 b) 2.0 c) 3.0 d) 4.0 e)* 5.0

You can find the vertical distance h traveled by knowing that the vertical speed at the maximum height is 0

$$v_{yf}^2 = 0 = v_{y0}^2 + 2ah = 0 = (4.0)^2 - 3.2h \Longrightarrow h = 5 \text{ meters}$$

10. A 4.0 kg mass starts from rest and is acted upon by a constant force. If the mass moves 64 m in 4.0 s, what is the magnitude of the force in Newtons?

a) 4 b) 8 c) 16 d)* 32 e) 64

From the mass moving 64 m from rest in 4.0 s at constant acceleration then you know the acceleration.

$$x(t) = x_0 + v_0 t + \frac{1}{2}at^2$$

From the data given $a = 128/16 = 8$ m/s^2. To get the force you use Newton's Second Law $F = ma = 4(8) = 32$ Newtons.

11. A 2 kg cart collides with a 8 kg cart. During the collision which car experience the greater force?

a) The 2 kg car b) The 8 kg cart c)* The forces are equal in magnitude but not zero
d) The net force on either cart is 0 e) impossible to say which force is greater

Newton's Third Law says that forces between two masses come in pairs, and the forces are equal in magnitude but opposite in direction. These are action/reaction forces.

12. A book is at rest on a horizontal table. A lipstick is at rest on the book. The forces acting on the book are

a) the weight of the book and the weight of the lipstick

b)* the weight of the book, the weight of the lipstick, and the normal force from the table
c) the weight of the book, the normal force on the lipstick, and the normal force from the table
d) the weight of the book, the weight of the lipstick, the normal force on the lipstick, and the normal force from the table
e) the weight of the book, the weight of the lipstick, the normal force on the lipstick, the normal force from the table, and the weight of the table.

The key phrase here is *forces acting on the book.* So automatically, the normal force on the lipstick is not counted, nor is the weight force of the table. The normal force of the table on the book is the sum of the book's weight and the weight of the lipstick.

1. During a tennis match, a player serves a ball with a speed of 23.6 m/s with the ball leaving the racquet in the horizontal direction at a height of 2.37 m off the ground.

a) How long does it take the ball to reach the net if the net is 12 m away from the racquet? (6 points)

The time that it takes the ball to reach the net 12 m away in the horizontal direction depends only on the (constant) horizontal velocity component of the ball:

$$v_{0x} = v_0 \cos\theta_0 = v_0 \cos 0 = v_0 = 23.6 \text{ m/s}$$

$$t = \frac{12 \text{ m}}{23.6 \text{ m/s}} = 0.5085 \text{ s}$$

b) If the net is 0.9 m high, does the ball go over the net? If so, by how much does it clear the net? If not, by how much does it hit below the top of the net ? (7 points)

The y position is governed by the equation

$$y(t) = y_0 + v_{0y}t - \frac{1}{2}gt^2 = 2.37 - 4.9t^2 \text{ (in meters)}$$

In this case $y_0 = 2.37$ meters, and $v_{0y} = 0$ since the ball was given only a horizontal component. Therefore, at $t = 0.5085$ seconds (from part a) the vertical position at the net is

$$y(t = 0.5085) = 2.37 - 4.9 \cdot (0.5085)^2 = 1.10 \text{ meters or 20 cm over the top of the net}$$

2. A somewhat daring cowboy is sitting on the branch of a tree. He sees a horse coming towards him at a constant horizontal speed of 10.0 m/s. He decide that he will drop from the tree branch onto the horse, after he estimates that the horse's saddle is 3.00 meters vertical distance below the tree branch.

a) How long in seconds will the cowboy be falling, assuming that he does land on the horse's saddle (6 points)

The cowboy will drop 3.0 m. We get this time of fall from

$$y(t) = y_0 + v_0 t - \frac{1}{2}gt^2$$

In this case we take $y_0 = 3.0$, $y(t) = 0.0$, and $v_0 = 0$

$$0 = 3.0 - 4.9t^2 \Longrightarrow t = 0.782 \text{ seconds}$$

b) How close in meters should the horse be in horizontal distance when the cowboy drops from the branch, assuming that the cowboy does land in the saddle? (7 points)

The horse is traveling at constant speed 10.0 m/s. So in this time 0.782 s, the horse will travel exactly 7.82 m.

3. A 1.00 kg mass is observed to accelerate at a value of 10.0 m/s^2 in a direction 30 degrees North of East (horizontal). A force $\vec{F}_2$ is acting on the mass in the vertical (North) direction with a magnitude of 5.00 N. What is the magnitude of the force $\vec{F}_1$ which is acting in the horizontal direction on this mass which causes the observed acceleration? (14 points)

The net force on the mass is computed from Newton's Second Law

$$\vec{F} = m\vec{a}$$

Since m is given as 1.00 kg, and $a = 10.0$ m/s^2 in the direction 30 degrees North of East, we have $\vec{F} = 10.0$ Newtons, also at 30 degrees North of East.

The horizontal component of $\vec{F}$ is $10.0\cos(30) = 8.66$ N and this is the magnitude F_1. The $\vec{F}_1$ force also acts to the East.