1. There are 2.54 cm in an inch, and therefore $2.54 \times 36/100 = 0.914$ meters in a yard. So in 1 yd^2 there are 0.914^2 m^2 = 0.8361 m^2 and in 1 acre, there are 4840×0.861 = 4047 m^2 in an acre.

2. Time taken to go north is 300/10 = 30 seconds. Time taken to go west is 400/20 = 20 seconds.

   Total magnitude of displacement is 500 meters (a 3, 4, 5 triangle). Magnitude of average velocity is 500/(20+30) = 10 m/s.

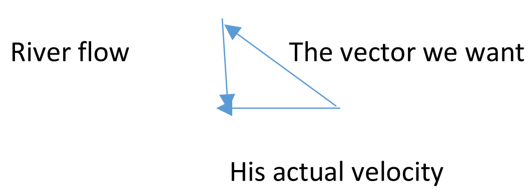
   Speed is total distance traveled divided by time = (300+400)/(20+30) = 14 m/s.

   The difference between the two is 4 m/s.

3. We need to differentiate the formula with respect to time to get **v**(t) = (20t)**I** + 15t^2 **j**
   Then we differentiate again with respect to time to get **a**(t) = 20**i** + 30t**j**
   We put t = 0.5, and we get **a** = 20**i** + 15**j**, which means that magnitude of the acceleration is the vector sum of these two components (a 3, 4, 5 triangle) which gives 25.

4. First we find how fast it is going. That is most easily given by v^2-v_0^2 = 2ax, and so $v = \sqrt{(2 \times 1 \times 3)} = \sqrt{6}$ = 2.44 m/s. Then we need to find how long it takes to fall. That is, because only up-down direction is important and there is no initial velocity in this direction, 10 = 0.5gt^2 and so t = 1.428 s. So now we know how far it moved horizontally in that time, 2.44 x 1.428 = 3.5 meters.

5. Here is a relative motion question about crossing a river as promised in class. The vector of his velocity with respect to the water is the unknown. The water with respect to the bank is 0.5 m/s, and the resultant (sum of the other two) has a velocity of 250/360 m/s.



Yet another right angle triangle, and the vector we want has length (corresponding to his speed) of $\sqrt{(0.5^2 + 069^2)}$ = 0.86 m/s

6. If the velocity is constant the net force on it is zero. As one force is of magnitude 2 N, there must be an equal and opposite force (i.e. of magnitude 2N) canceling it.

   I'm happy to say this was the question with the highest success rate.

7. First let's find the acceleration by considering the two blocks to be one big block. There are two friction forces pushing against the applied force. One is 2.0xgx0.51 = 10N (block m), the other is 5.0xgx0.51 = 25N. Therefore the net force accelerating the two blocks is 70-10-25 = 35N, and F=ma gives us an acceleration of 5 m/s^2

   Now look at block m. It has a force pushing it from block M which is what we want to know, it has a frictional force of 10N worked out above, and it accelerates with a value we also know. So, F=ma gives: F – 10 = 2.0 x 5, and F = 20 N.
   (There are other ways of working this out……)

8. A simpler version of some homework questions. We know that the cos(37) = 0.8 and sin(37) = 0.6. We work out how LONG it takes to reach the wall by looking only at the x motion. t=10/(20*0.8) = 0.625 seconds. Now let's work out how high it is at that time. y = 20x0.6*t – 0.5*9.8*t^2 . That gives y = 5.6 meters.

9. This uses the properties of dot produces. **A.B = |A||B|**cos(θ)
   |**A**| = 13 and |**B**| = 5
   So 15 + 48 = 13*5*cos(θ)

   so θ=14^0
   This question had the second highest success rate on the exam.

10. At t=2 seconds, it is traveling at 208 m/s. It then drops a package, and the time taken for it to hit the ground is independent of any x velocity, and is given by 100 = $0.5gt^2$ and so t = 4.51 seconds, so that is 208*4.51 meters from the starting point. The plane, however, has moved horizontally 208*4.51 + 0.5*4*4.51^2, and so the difference in x is 0.5*4*4.51^2 = 41 meters.

11. The laws of physics are the same in all inertial rest frames. Therefore there is no way a little experiment like this can tell us if the elevator is going up or down, or detect it velocity. It CAN tell us if it is accelerating. We know how long it would take to hit the floor if it were not accelerating:

    y = $0.5gt^2$

    gives us t = 0.49 seconds, which is much less than 0.7s. Therefore the elevator is accelerating downwards (if it were in free fall, the number 0.7 would be infinity!)

    This question had the lowest success rate of any question.

12. This diagram was on the homework. You know that as the velocity is constant the NET force has to be zero. There are three forces acting. One unknown and horizontal, one is straight down and is 6.0*9.8 = 58.8 N, and one is the normal force which is at 30^0 to the vertical. Vertical forces must add to zero, so that means that $F_N$cos(30^0) = 58.8. Equating horizontal forces, we get $F_N$sin(30^0)=F. Therefore F = 58.8/1.73 = 34 Newtons

13. The tension in the string is greatest when the mass is at the bottom of the circle. At that point we have to use F=ma, where T (the tension) is up, the gravitational force is down, and the acceleration is v^2/R (up), so T - mg = mv^2/R

    So T = 2*9.8 + 2*3*3/0.5 = 19.6 + 36 = 56 Newtons

    There was a homework question very similar to this.

14. The force of the truck on the car is the same as the force of the car on the truck (Newton's 3rd Law). We know that the truck as M = 2000 kg and is accelerating at 1 m/s, so that means a force of 2000 N (Newton's Second Law).

15. The velocity is the rate of change position, so it is the place on the graph which has the greatest slope (positive or negative), and this is clearly point a.

16. A key point here is that it isn't moving, and there is no indication that it is even close to moving, so the net force is zero. Therefore we cannot use the laws of friction. We know that the friction force is equal and opposite to the x-component of the applied force, which is $10x\cos(\theta)$ = 8 N

    There was both an H-iTT question and a HW question that stressed this physics.

17. A straightforward question though not the easiest computationally – you need to know that the maximum friction force which is $F_N\mu_s = 0.8 \times (mg-F\sin(40^0))$, and that has to equal the horizontal component of the applied force, which is $F\cos(40^0)$.
    So 0.8*(3*9.8) – 0.8*F*0.642 = F*0.766
    F = 18.3 Newtons

18. We can integrate with respect to t and find that $v(t) = 6t - t^2$ (there's no constant of integration as it starts from rest). That means that the velocity is zero when t = 6 seconds. That must be where it turns around. The displacement is found from integrating again so is $x = 3t^2 - t^3/3$ (again, at t=0, x=0, so no constant of integration needed). So we have x = 3*6*6 = 216/3 = 108-72 = 36 meters.

19. A key point here is that just after it is released it is going at the velocity it was just before the release, but the acceleration is only the acceleration due to gravity (Newton's 2nd Law). Therefore, just after release:

    V = 4**j** + 3**i** **.** One second later it will have accelerated down by 9.8 m/s^2, so **V** = -5.8**j** + 3**i** and the magnitude of v is 6.5 m/s

    Unfortunately we introduced a bug during the editing of this question, and 6.5 did not appear as one of the answer. 6.8 was the closest. We could have decided to accept 6.8 as the correct answer as it was the closest, but this seemed a little unfair to those who had been put off by the discrepancy. Therefore we decided to grade everyone correct for this.

20. They are equal masses, so there will be no acceleration. So clearly it will be moving 5 m/s when it hits the ground. Newton's First Law!