Mission Impossible II

1. A Russian scientist named Nekhorvich is working in his laboratory. While working on three sample cultures, Nekhorvich mentally laments in his participation in creating such a dangerous force of nature. Where was his laboratory located?
2. What type of scientist was Nekhorvich?
3. While attempting to create the ultimate cure, Nekhorvich had to create an ultimate virus? What was the name of his cure? What was the name of his super- virus?

4. Nekhorvich, having weeks to plan, decides to journey to Atlanta and give the virus to the U.S. Government, in order to expose his employer's criminal plans. Nekhorvich then destroys two of the three cultures of the virus, and then in injects the third into his arm. Why do you think he did this? (It seems to be a rather stupid thing to do).

5. How long does it take for the virus to advance beyond the point where the cure won't save Nekhorvich?
6. Who does Nekhorvich summon to escort him to Atlanta?
7. While suffering from the virus' effects, Nekhorvich makes it onto a Boeing 747. When the plane reaches the Colorado Rockies, the plane is seized by unknown agents. What happens to all of the other passengers and crew?
8. Who kills Nekhorvich? Why?
9. Who is Sean Ambrose? Who is Ethan Hunt?

10. Meanwhile, in Texas, the real Ethan is climbing to the top of a steep cliff using nothing but chalk. What is the chalk used for?
11. At one point, while Ethan is several hundred feet above the flats, he comes to an impasse, and decides to let go. He falls about 15 feet, and catches himself by grabbing a small ledge on the way down. Determine whether or not this is possible.

a. How many meters are in 15 ft.?
b. How long does it take for Ethan to fall 15 ft? Use: $\Delta y = v_{oy}t + \frac{1}{2}gt^2$; where $g = -9.8\ m/s^2$, and $v_{oy} = 0$ m/s.

c. What is his velocity, after he falls 15 ft? Use: $v_y = v_{oy} + gt$

d. For Ethan to catch himself, what force in "N" would he need to decelerate to 0 m/s again?

   Use: $F = (mv' - mv_y)/t$ where m = 80 kg; v' = 0 m/s; v_y = your answer from #11 (c) and t = 0.25 sec. (this is a reasonable time for his catch).

e. Change your "Newtons" to "Pounds". Note:(4.45 N = 1 lbs.)
f. Is this a reasonable force for Ethan to use?

12. No sooner has Ethan reaches the top, an IMF helicopter arrives and fires a rocket at him, which lands beside him un-exploded, and deposits a pair of sunglasses that contain a message from his immediate superior. How do these sunglasses relay the message?

13. His superior informs Ethan the Ambrose and his team have gone rogue, and he is to assemble a team of his own and report to Seville for his briefing and for more details. While two of his three-man-team are of his choice, the last must be Nyah Nordoff-Hall, a civilian, yet highly-professional & expert specialist. What was Nyah's specialty?

14. Nyah remains a fugitive form multiple law-enforcement agencies around the world, but Ethan catches her in the middle of a job. What was she doing?

15. Later, Ethan tracks Nyah down in his car, and they have a semi-friendly car chase, which ends in them almost crashing and falling from a steep cliff-edge. During the car chase, Nyah slams her car into Ethan's car in a attempt to force him off the road. Let's take the following hypothetical accident. Say Nyah impacts Ethan's car in a perfectly inelastic collision (the cars stick together). If she was originally traveling at a 30° angle to Ethan's direction, find the velocity of the cars immediately after the collision assuming they were each traveling at 90 miles per hour just before the collision. [Use $m_1v_1 + m_2v_2 = (m_1 + m_2)v$] Assume $m_1 = m_2 = 1000$ kg

16. Later that evening, Ethan meets his superior in the local IMF office. Michael tells Ethan of Nekhorvich's death, along with that of Gradsky, Nekhorvich's assistant who died some time earlier. Ambrose was sent to assume Ehan's image and escort Nekhorvich to the United States, as Ethan himself failed to mention where he was going on holiday and so couldn't be reached. The IMF knows virtually nothing about the viruses, or what Ambrose is planning. Ethan's mission is to find out and stop him. Nyah is to be an inside agent, as she had a relationship with Ambrose that she eventually ended and Ambrose has been desperately wanting her back ever since. Nyah, after realizing Ambrose's actions have led to people's deaths, agrees to the plan, and Ethan arranges from her to be falsely arrested, and information on this to be sent to Ambrose. As Ethan predicts, Ambrose arranges for Nyah's freedom and for her to be brought to his secret compound on an island. Ambrose completely believes Nyah to truly wanted to return to him for his actions, but Ambrose's right-hand man, Hugh Stamp, remains vigilant and suspicious. Nyah is forced to seduce Ambrose to solidify his trust in her. All the while, her progress is monitored by Ethan and his team-mates; Luther and Billy.
    a. How is this done?
    b. Is it possible to track someone by satellite from a small cylinder injected into the skin? Explain.

    c. What wavelength size of electromagnetic wave can a small cylinder emit? (Note: The wavelength should be at least the size of the antennae). What electromagnetic wave could this be?

    d. Could this electromagnetic wave not be detected by Ambrose? (If we wanted to)

    e. What would be a power source for the injected cylinder?
    f. To your knowledge, has this ever been done before? Explain.
    [Try searching the internet for animal tracers] What was the problem?
    g. Can you secure an electromagnetic wave and not allow others from picking it up? Explain.

17. Eventually, at a race track, Ambrose is caught talking John C. McCloy, the ruthless CEO of Biocyte, the corporation that employed Nekhorvich. Though nothing is heard, McCloy is shown a disk of the effects of the "Virus" on Gradsky, which occur 20 hours after exposure. Nyah is able to get Billy a copy of the disk, but Ambrose notices her putting it back in his jacket.
The disk shows the virus infecting and destroying cells in the blood stream. It clearly shows that it is red blood cells being infected. Viruses, in order to replicate, require the cell's DNA replication machinery. Mature red blood cells in the circulation no longer possess this machinery since they no longer have a nucleus or DNA. So,,,,,is it possible for the virus to replicate like shown? Explain.

18. McCloy is abducted by the IMF team and, doped up on drugs and setting up a fake hospital room, McCloy believes he is infected with the virus, and is visited by Nekhorvich's ghost. Nekhorvich manipulates McCloy into revealing he ordered the virus to be developed as a bioweapon for profitable military applications, and then bought the services of Ambrose and his team to steal the virus back after Nekhorvich's theft and escape, but now Ambrose has become ambitious, and is demanding McCloy to pay a lot of money for the virus samples, to which he agreed to. Who is the actual Nekhorvich ghost?
19. At the same time, Nyah is summoned to a meeting with Ethan, who has briefly broken into the compound to give further instructions. Is this really Ethan?
20. In the final scene involves an out-of-control high-speed motorcycle chase between ou hero and his vicious adversary. At one point Ethan jumps off the side of his motorcycle going full speed. He maintains contact with it by holding on to the handlebars as he skids alongside of the motorcycle, in a standing position. He does this so that sparks fly off of the bottom of his boots and obscure the view of his pursuer. Analyze the forces acting on his feet and hands in this scenario.

21. Toward the end of the chase, Ambrose turns to face Ethan in a spine-tingling showdown. The two square off several hundred yards apart and rev their engines for many tense moments before acceleration full throttle directly towards each other. They must be going 50 miles per hour at least, and just before the inevitable crash the two simultaneously leap off of their motorcycles and crash into each other in mid-air. As Ethan's motorcycle flips up into the air it disintegrates in an obligatory movie explosion. They grapple with each other as they veer off perpendicular to the line of the impact and fall together over a cliff, landing on the ground some 20 feet or so below where they collided. Unfortunately Ethan has lost his gun during the grapple, and it lands about a second before they do, rolling off to the side. The two characters seem hurt by the fall, or at least the wind gets knocked out of them pretty hard. However, they regain their strength sufficiently for the final hand-to-hand contest. Our task will be to analyze the scene from just before the two crash into each other to just after they hit the ground.
    a. First of all we know that momentum must be conserved from before until after the collision. In addition, this is a perfectly inelastic collision because they stick together afterwards. Without doing any calculations it should be clear that momentum is not conserved in the scene. Why? (Hint: Does the total momentum stay along the same line)

b. Using the principle of conservation of momentum let's determine what their motion should be immediately after the collision. We can reasonably estimate that they are going about 50 miles per hour (22 m/s) on their motorcycles, which means that when they collide they have a relative velocity of around 100 miles per hour! Let's assume they have equal speeds. It looks like Ambrose may be a bit beefier than Ethan, so let's estimate their masses to be about 90 kg (198 pounds) and 80 kg (176 pounds), respectively. The two appear to hit almost head-on but slightly off center, and the collision causes a slight rotation. This means that in addition to the linear momentum described above, angular momentum is also conserved. For the sake of simplicity we will only deal with the linear momentum. It shouldn't significantly affect our results. Therefore calculate for "v":

   Use: $m_1v_1 + m_2v_2 = (m_1 + m_2)\, v$

   Remember that v_2 is negative for direction. (Expect "v" to be negative.)

c. They were driving their motorcycles parallel to the cliff edge and at least several meters from the edge, and yet they fall over the ledge. How can this be? Does your calculations tell you this? Can a strong wind do this? Do you see any meteorological disturbances in scene?

22. Let's analyze the forces involved in the mid-air collision. Human bodies really don't have much padding (particularly in the head), and a collision between two people is a hard collision lasting on the order of 0.01 seconds. Our antagonists are also in pretty food shape without much body fat to cushion the blow. In addition, the collision seems to involve primarily the upper halves of their bodies with direct contact between their respective heads. Because $F = \Delta p/\Delta t$ we can determine the forces on each of the combatants as soon as we find Δp (momentum change) for each.
    a. Find the Δp of Ethan during the collision: Use $\Delta p = mv - mv_o = m\,(v - v_o)$ where m = mass of Ethan = 80 kg; v = answer from #21b; v_o= 22 m/s
    [Note: Δp has a unit of "kgm/s"]

    b. We know according to both Newton's third law and conservation of momentum that Δp for Ethan = $-\Delta p$ for Ambrose. What kind of force is required to change this momentum?
    Use $F = \Delta p/\Delta t$. (Let's be conservative and give them the benefit of the doubt, and assume a longer collision time (0.015 sec) and see what happens.) Note: "F" has the unit of $kgm/s^2 = N$

c. It is estimated that bones will break when experiencing forces of about 90,000 N. Therefore, does it look like Ethan might break a rib or two?
d. Data on car accidents suggests that a person will survive a crash if the whole body impact pressure is less than 190,000 N/m² for less than 0.07 sec. Fifty percent of crashes are fatal when pressures exceed 340,000 N/m². Calculate the average pressure they experience during the collision. The entire front surface area of the body is about 0.7 to 0.9 m². However, it is only the upper right halves of their bodies that actually impact (0.3 m² to 0.4 m² or so). Let's split the difference and call it 0.35 m². Use Pressure = P = F/A

e. Is it possible for these characters to survive the pressures calculated above?
f. Accelerations of the head exceeding 150g (150 times the acceleration due to gravity) are usually fatal. What accelerations do the characters experience? Use F = ma where the "m" is the mass of Ethan and Ambrose and F is the answer from part d above.

g. Are the accelerations near the fatality zone?

23. Even if they survive what does this feel like, and what nonfatal damage does it do? Is it even possible to get up after experiencing something like that? The damage would essentially be the same as running headlong into a brick wall at a speed of 50 miles per hour. You can imagine how badly these guys should feel during and after impact. Amazingly, though, not only are they not seriously hurt by the collision or even in traction, but they are able to wrestle with each other in mid-air before crashing into the ground 20 feet (6 m) or so below. It isn't until they impact the ground that they do look really hurt, or at the very least, they each appear to have had the wind knocked out of them. What humongous force must have been exerted on them when they hit the ground to cause each of them such discomfort?

a. Because they are in free-fall, calculate their vertical velocity when they hit the ground:
   Use the kinematic equation: $v_y^2 - v_{oy}^2 = 2\,g\,\Delta y$ where $v_{oy} = 0$ m/s in the y-direction; $g = -9.8$ m/s² and $\Delta y = -6$ m

b. Calculate the force of impact with the ground that each does?
   Use $F = \Delta p/\Delta t$ where the $\Delta t = 0.015$ seconds; $\Delta p = m(v - v_o)$
   Remember that v = final speed on the ground = 0 m/s
   and v_o = answer from part-a- above.

c. Are these enough forces to break a bone?
d. Is this enough force to kill them?
e. How do these forces compare with the forces calculated in #22.

24. In the above problem, we used the constant downward acceleration due to gravity ($g = 9.8$ m/s²) to calculate the change in speed during the fall. We know that this value of "g" is effectively a constant at the surface of the Earth regardless of the mass of an object, unless there is significant air resistance. As long as air resistance is small, all objects accelerate at the same rate towards Earth. For relatively heavy or dense objects falling short distances, air resistance will have very little effect. Is it possible for Ethan's gun to hit ground well ahead of him? Explain.