Speed Movie Handout

The movie opens with a madman holding a group of hostages in an elevator. The cable has been blown in half and the elevator is suspended perilously by it's emergency brakes. These too, have been wired with charges which will be blown it the madman's demands for cash go unmet.

A daring L.A. cop and his sidekick descend the shaft and connect a cable to the top of the elevator. Their clear thinking saves the day, at least after a series of close calls thwarted in his evil efforts, the madman expresses his disdain by setting up yet another bombing attempt.

He rigs a bomb underneath a city bus and configures it so that it can be blown three different ways. There's the usual timer, a remote radio-activated detonator, and a speed-activated switch. Once the bus exceeds 50 mph (81 km/hr) it can never go below 50 mph again without being blown up. Of course, the bus driver doesn't listen to Reeves' impasssioned exhortations to keep it below 50, and so the stage is set for a really wild ride.

After some more hair-raising events Reeves finally ends up in charge of the bus with Annie driving. The bus runs into the traditional L.A. traffic jam on the freeway and has to depart for city streets, leading to all sort of entertaining mayhem as the bus mows down street signs and sideswipes everything in sight.

1. When the bus sideswipes a car parked behind a tow truck the car travels up the truck's tilt ramp and flies forward through the air for some distance. Although the camera gives us few details of the actual collision, would this sideswipe impart the momentum to this stationary car for it to zoom up a ramp and go airborne? Yes or No
Why?

2. In scene 11 bus 2525 needs to make a 90-degree turn in the city while maintaining the 50 mph speed. However, a bus can’t actually make a sharp 90-degree turn. To change direction by 90 degrees, it would need to follow a curved semi-circular path. If the road is no wider than the bus then the turn is clearly impossible. The wider the road, the bigger the circle we can travel and the easier it will be to negotiate the turn successfully. From watching the scene it is hard to get the road’s exact width, but it looks like they are traveling on a three-lane one-way street, and they turn onto a sex-lane two-way street, so fortunately, the road gets wider as they go through the turn.

Because the road is flat (unbanked) we know the only possible force acting on the bus as a centripetal force will be the force of static friction. The formula for centripetal force $F_c = \frac{mv^2}{r}$;

The formula for Static friction is f = μF_N; The formula for Newton's 2nd Law F_y = mg; Using Newton's 3rd law, (for every action there is an equal but opposite reaction), in the vertical y direction, then F_N=mg ; Therefore f = μmg

The coefficient of static friction, μ, between tire rubber and asphalt is about 0.8, so if the friction is the Centripetal Force then, F_c=f or $\frac{mv^2}{r}$ = μmg where m = mass of the bus; r = minimum radius of circle; g = acceleration due to gravity = 9.8 m/s².

a) Solve for the r in the final formula above:

b) Substitute the given data and calculate the minimum radius of the circle around which the bus can successfully travel without skidding out. Note: 50 mph = 22 m/s

c) A lane is usually about two feet wider than a average-sized car of a width of 5 ft or so. Let's be generous and say the lanes are eight feet or 2.5 meters wide. Allowing for a little bit of shoulder, we'll say the three-lane road has a width of 9 meters, and the six-lane road a width of 18 m. Draw a scaled diagram below, and see if you can approximately determine the maximum radius of curvature from your diagram. (In other words, draw a ¼ circle from your outside lane edges)

d) If you've sketched your curve correctly to scale, with a ¼ circle radius, you'll notice that a 62 m radius won't do. Using a compass, you'll notice that dimensional corner will give you a 40 m radius. Does it look like the bus is going to make the turn?
e) Will the bus skid into the embankment?
f) Will the bus go *kaboom* at this point in the movie.
g) However, would they make the turn if the bad guy set the bomb to blow when the speed dipped under 25 mph instead of 50 mph? [Hint: That is ½ the v]

h) Would they make the turn if the coefficient of friction is just a little higher? If the tires have particularly good traction, or if the road has a rougher texture than the average street. What coefficient would work?

i) Maybe we underestimated the width of the road that the bus is turning onto. (It's hard to tell with the quick cuts and rapid camera work) What else could happen to make it work for them and maintain a 22 m/s speed. (Another car….retaining wall…etc.)

j) What if the turn is banked. How would this help the centripetal force needed to make the turn?

3. The police finally directs the bus to an unused section of highway, but alas it requires a hard left turn.

a) What do the passengers do to prevent it from rolling?

b) What does the bus do?

c) Is this likely? Yes or No? Why?

4. The highlight of the whole movie occurs on the empty freeway. No one realized that it's missing a section of an overpass bridge until it's too late. How big is the section?

5. Since they can't turn around, Reeves decides to speed up and jump the gap.
What is the take-off angle?

6. Is the top of the bridge a lengthy flat spot or and incline spot?

7. What is the acceleration due to gravity in $\frac{m}{s^2}$? [g =(This g value is constant for all masses)]

8. If an object falls from rest, how fast will it be falling in 5 seconds?

9. If you are accelerating at a constant rate, (and when falling you usually are), then the average speed would be half of the final speed. So, what is the average speed?

10. If distance = (average speed) x time, how far would an object fall in 5 seconds?

11. Use the formula $d = \frac{1}{2} g t^2$ to find the distance fallen from rest in 5 seconds?

12. How does #9 & #10 compare?

13. If the bus is travelling above 50 mph, (let's give them the benefit of the doubt and assume it is going 75 mph (33.5 m/s)), how long will it take for the buts to travel horizontally 50 ft (15.24m)? Use $d = v \times t$.

14. In the time calculated above, the bus will have fallen $d = \frac{1}{2} g t^2$.
Calculate this distance:

15. If the bus took off from a flat surface and tried to land on another flat surface the same height, as it appears to in the video, would this possible?Explain.

16. If the bus would have fallen the calculated distance indicated in #13, sketch the crash instant on the other side of the gap?

17. To clear the 50 ft gap on the freeway, a needed is a jump, (an angled surface). If the bus is

taking off (literally) at a 30 degree angle, at 75 mph then there will be a motion upwards (vertical) and a motion forwards (horizontal). These motions are independent of each other, which means you can split them up and work out how far the bus travels, upwards/downwards and forwards/backwards. So, for the vertical motion the speed at which the bus is going upwards initially is: v = 33.5 m/s x sin(30)=????
Calculate:

18. The bus would decrease in speed upwards due to gravity, until it stops and then start falling, like throwing a ball upwards.

a) How long would the bus take to rise to the top of it's flight?
{ Note: (Final speed - initial speed)/(acceleration due to gravity) = time}

b) Calculate the Average speed =(initial speed + final speed)/2 for a constant acceleration of g.

c) Calculate the height climbed:
{Note: h = (average speed) x (time) =?????}

d) To fall this height (h) due to gravity will take how long?

e) So what is the total time of the entire trajectory?
{Note: This is how long the bus needs to make the jump of 50 ft}

19. Calculate the horizontal velocity v = 33.5 m/s cos (30) = ????

20. Calculate the range of the trajectory? {Note: X=(horizontal velocity) x total time}

a) How many feet is this? {Note: 3.28 ft = 1 meter}

b) Will the bus fly over the hole?

21. We haven't accounted for deceleration due to wind resistance. (This is a variable) Would this reduce or increase the distance jumped?Explain.

22. A 30 degree ramp might be a little extreme. Try doing the above calculations, (#16-19), to see if the bus would make it at 75 mph on a 5 degree ramp.
[Show Work]

a) Vertical velocity =

b) Time in the air =

c) Horizontal velocity =

d) Range of jump in feet =

23. After watching the jump closely, the bus's front end rose. This would be caused by the bus driving up a short ramp, giving it upward impulse, or it was lifted by a kicker plate. Which do you believe happened? Explain.

24. After another series of improbable escapes and near misses glossed over by rapidly changing camera angles and dramatic acting, we end up at the grand finale. It starts with the usual back-off or-I'll-blow-up-your-girlfriend stuff and progresses to a typical fight scene on top of a moving subway car. Although it was off camera, both our hero and the bomber evidently scrambled up the special ladder labeled "this way to the top of the subway, visitors welcome". The bad guy did fail to take note of the sign which said, "watch you head".
Back inside the car, the hero finds that the brakes are shot, or at least the controls for them.
Since the train is racing toward the end of the line he pushes the speed control to maximum, after deciding it's better to speed it up and jump the track rather than pile into a barrier at the end.

a) If the speed control works in the upward direction then wouldn't it work in the downward direction?

b) Wouldn't a low-speed collision into what just might be a properly-designed barrior be better than a high-speed track-jumping venture into heaven knows what? Why?

25. Certainly "Speed" had a unique premise and succeeded as entertainment. However, it will definitely be remembered for it's fake bus jump. By the way, most non-physics types intuitively consider the bus too massive for jumping. Does the mass count on whether the jump is possible or not possible?