The Effect of Gravity

Let's return to a situation we addressed in our second session.

In our second session we imagined ourselves enclosed in an elevator. We had a super-ball that we threw across the elevator, and we used it to draw a conclusion that is known as ***the equivalence principle***. The essence of the equivalence principle is that, from your perspective enclosed in an elevator, being in an accelerating elevator is absolutely equivalent to the system of you plus the elevator being in a uniform gravitational field. There are no experiments that you can do, inside the elevator, to distinguish between the two situations.

We addressed two cases in particular:

Case 1 – You are in an elevator that is either at rest or moving with constant velocity, far from any gravitational influences. Compare this to being in an elevator in free-fall in a uniform gravitational field. A superball you throw across the elevator travels in a straight line according to you – you can't tell the difference between the two situations, although they look different to Superman who is outside the elevator using his x-ray vision to see through the wall of the elevator.

Case 2 – You are in an elevator that is accelerating, far from any gravitational influences. Compare this to being in an elevator that is stationary in a uniform gravitational field. A superball you throw across the elevator travels in a parabolic path according to you – you can't tell the difference between the two situations, although they look different to Superman who is outside the elevator using his x-ray vision to see through the wall of the elevator.

Let's now replace the superball by a beam of light, released from a laser pointer you are holding. Does the equivalence principle still hold?

You are in an elevator that is either at rest or moving with constant velocity, far from any gravitational influences. You shine your laser pointer across the elevator. Describe the path of the light beam from your perspective inside the elevator, and from Superman's perspective outside the elevator.

You are in an elevator that is in free fall near the Earth's surface, which we can assume to be in a uniform gravitational field. You shine your laser pointer across the elevator. Describe the path of the light beam from your perspective inside the elevator, and from Superman's perspective outside the elevator.

You are in an elevator that is accelerating, far from any gravitational influences. You shine your laser pointer across the elevator. Describe the path of the light beam from your perspective inside the elevator, and from Superman's perspective outside the elevator.

You are in an elevator that is at rest near the Earth's surface, which we can assume to be in a uniform gravitational field. You shine your laser pointer across the elevator. Describe the path of the light beam from your perspective inside the elevator, and from Superman's perspective outside the elevator.

Now let's change the direction the laser beam is going. We'll direct the beam from the bottom of the elevator toward the top, in the direction the elevator is accelerating, if the elevator has an acceleration. Think about whether we should see a Doppler shift of the light beam when it arrives at the top of the elevator.

You are in an elevator that is either at rest or moving with constant velocity, far from any gravitational influences. You shine your laser pointer from the bottom of the elevator toward the top. Do you expect the beam to be Doppler shifted?

You are in an elevator that is in free fall near the Earth's surface, which we can assume to be in a uniform gravitational field. You shine your laser pointer from the bottom of the elevator toward the top. Do you expect the beam to be Doppler shifted?

Are these two situations described above different, or still equivalent?

You are in an elevator that is accelerating, far from any gravitational influences. You shine your laser pointer from the bottom of the elevator toward the top. Do you expect the beam to be Doppler shifted?

You are in an elevator that is at rest near the Earth's surface, which we can assume to be in a uniform gravitational field. You shine your laser pointer from the bottom of the elevator toward the top. Do you expect the beam to be Doppler shifted?

Are these two situations described above different, or still equivalent?
