Chapter 8
Free-Falling Bodies 2: Transcript

The transcript here picks up after Dave gave the students the worksheet and had them begin working to answer the questions. Ron was the first student to call Dave over to talk about his ideas.

1. Ron: Mr. Hovan.

2. Dave: Yeah.

3. Ron: If there wasn't no air the ball would be coming down very slow.

4. Dave: If there was no air?

5. Ron: Yeah.

6. Dave: So you're saying it would come down slower if there was no air?

7. Ron: Very slow. Like this, very slow, (*lowering a book to the ground*) steady, because there isn't any air.

8. Dave: So you're saying air makes things fall faster.

9. Ron: Yeah … How high is this thing? Like if you dropped it, how high is it?

10. Dave: For which one?

11. Ron: For number one.

12. Dave: Number one, it doesn't matter, any height.

13. Ron: I mean, if you drop this from a certain height, it wouldn't hit the ground.

14. Dave: Not at the same time?

15. Ron: No.

16. Dave: So are you saying the higher up that you drop something, like, the less likely they are gonna hit the ground at the same time?

17. Ron: Yup.

18. Dave: Okay why?

19. Ron: Because it's heavier. See, I was gonna say if I got—like, if I stand on top of this, right, and I drop this [*binder*] along with this [*pencil*] ... the binder's gonna drop first.

20. Dave: That one's gonna drop first?

21. Ron: No.

22. Dave: No this one. Why?

23. Ron: Because it's a lot heavier.

24. Dave: So you're saying heavier objects fall faster than lighter objects.

25. Khalid: That's not true.

26. Dave: You don't think that's true? Why not?

27. Khalid: On Earth it's not true.

28. Dave: On Earth it's not true?

29. Khalid: Air resistance.

30. Dave: So air resistance plays a role in how fast things fall? Like how? How does air resistance affect how things fall?

31. Khalid: Like if you drop this book and this pencil, they're gonna hit the ground at the same time.

32. (*Ron gets up to pick up the book and the pencil*)

33. Dave: But … Okay just be careful near the equipment, here do it over here.

34. Ron: Right here?

35. Dave: Yeah. Actually, here, do it on that desk.

36. (*Ron drops the book and the pencil. They appear to fall at the same rate*.)

37. Khalid: See, it didn't. That's why I got an A in this class.

38. Dave: So wait-do you still think that heavier objects fall faster?

39. Ron: I mean, for real though, if I stand up on top of here and drop both of them, it's gonna land first, before that pen.

40. Dave: So you're saying that if you were up a lot higher, it would be more clear that this one would fall faster than the pen. Okay why do you think that?

41. Ron: I don't know, I just know! It's gonna happen.

42. Dave: Okay all right. I'm trying to get you to think about why that would happen. So that's what I want you to write down. Why do you think that would happen? Why do you think heavier objects would fall faster than lighter objects? (*to class*) Okay you've got about 5 minutes.

43. (*Dave begins walking around the room*)

44. Dave: How's it going?

45. Jada: I don't…know what to do. I mean I know what to do, but…I don't know.

46. Anita: (*inaudible*)

47. Dave: Okay, so have you answered number one yet?

48. Jada: I read it.

49. Dave: Okay. So if you need more space you can write it on the back … Okay, so do you agree with this student's statement about the two different objects falling?

50. Jada: Yeah.

51. Dave: You do?

52. Jada: Mmmhmm.

53. Dave: Okay, so I want you to explain why you agree with the student.

54. Tiera: Mr. Hovan.

55. Dave: Yes.

56. Tiera: If you drop a bowling ball and a small rock on the Moon, neither one of them would drop with it because there's no gravity up there.

57. Dave: So you don't think there's gravity on the Moon?

58. Tiera: No, because that's how space is.

59. Dave: So if you're really far away from massive objects like the Moon or the Earth or the Sun, then gravity is negligible, it's, it's like there's no gravity.

60. Tiera: So its…

61. Dave: So there is gravity on the Moon, yeah. So things do fall on the Moon. Do you think that, do you know if they fall faster or slower on the Moon? They fall slower. Any idea why?

62. Janice: Because … um … there's less gravity, right?

63. Dave: Right, so things accelerate slower on the Moon because the Moon is less massive than the Earth.

64. Tiera: So a bowling ball would drop first right?

65. Dave: On where?

66. Tiera: On the Moon.

67. Dave: Okay why?

68. Tiera: Because it's heavier.

69. Dave: Because it's heavier? So you think that heavier objects fall faster than lighter ones?

70. Tiera: On the Moon, they drop slower…

71. Dave: So are you saying that on Earth they would fall and hit the ground at the same time? But on the Moon they wouldn't? Okay so what's the difference between the Earth and the Moon? (*Pause*) … So why do you think that then?

72. Tiera: Because it's outer space and there's like, probably less gravity in outer space than it is on Earth.

73. Dave: Okay so gravity isn't as strong on the Moon as it is on Earth. That's true. But, so if gravity's weaker on the Moon, I mean, things aren't gonna accelerate down as quickly on the Moon, but why would, um, the fact that we're on the Moon like, affect which one hit first? Like wouldn't they both just hit the ground at the same time just at a slower rate, is that possible?

74. Tiera: So they're gonna hit at the same time?

75. Dave: That's what I want you to think about. That's what I want you to think about. (*to class*) So you've got about two minutes. I'm collecting these at the end of the period so you need to make sure that you have them done. How's it going?

76. Willie: I don't understand. I mean…

77. Dave: Okay, what don't you understand?

78. Willie: Because I don't want to be right or to be wrong. Is this like our opinion?

79. Dave: Yeah. It's your opinion.

80. Willie: Oh, it's not right or wrong?

81. Dave: No, I want you to explain your reasoning. I just want you to explain what you're thinking … Are you doing your work? ... Are you doing your work? ... Ebony, how are the questions going?

82. Ebony: They're going great.

83. Dave: They're going great?

84. Ebony: Yeah.

85. Dave: Good. (*six second pause, students chatting and working on sheets*) Shhh. (*eight second pause, students chatting and working on sheets*) Anita, can you not throw stuff in class please? (*21 second pause, students chatting and working on sheets*) Shhh, Okay, listen up, listen up, so I want you to go back to your desks, okay, back to your seats, please. And we're gonna discuss these questions, so as we're going through the questions, you can fill in responses if you think … hi … you can fill in more responses if you wanna add something to your answer, okay? You can change your answers if you want a little bit. Allan, can you pick that up please?

86. Allan: [*inaudible*]

87. Dave: Can you pick it up? Okay number one, can I have a volunteer to read number one? Khalid, go ahead.

88. Khalid: "A bowling ball and a small rock are dropped at the same time from the same height. Which one lands first? Here is a student answer: 'They land at the same time. If there were no air, the bowling ball would land first. But air resistance slows the bowling ball, so they land together' Do you agree with the student's reasoning? Disagree? Explain." I agree.

89. Dave: Okay so you agree that the bowling ball and the small rock are going to hit the ground at the same time. Okay. So why do you, how many other people agree? How many other people agree?

90. Dave: How many people disagree? All right, for those of you who agree, why do you agree?

91. (*Hands*)

92. How many people disagree?

93. (*Hands*)

94. Khalid: It's air resistance.

95. Dave: So what do you mean? What do you mean by "air resistance"?

96. Khalid: They gonna fall at the same time. They accelerate at the same speed.

97. Dave: Okay so that's what happens, right? And so we're trying to understand the reason why that happens. So you're saying it's air resistance. All right, so how does air resistance affect how they fall?

98. Khalid: Because it resists it.

99. Janice: Shut up, Khalid (*inaudible*).

100. Khalid: Am I right or wrong? It resists it.

101. Dave: So you're saying that the air resistance causes them to fall at the same rate.

102. Khalid: No. The air resistance will only allow them to go a certain speed.

103. Dave: The air resistance will only allow them to go a certain speed. So does the air resistance make all objects that are falling go at the same speed? Or does it depend on the shape or the mass of the object?

104. Khalid: Um like not like a sheet of paper like this (*waves a sheet of paper*)…can be balled up too.

105. Anita: It's the shape.

106. Dave: Uh huh. Okay so how does the air resistance affect the paper when it's spread out like that? As opposed to the … pencil (*inaudible*).

107. Jada: Because the, um, the particles … (*Janice puts one hand on top of the other*)

108. Dave: Okay all right, let me get one at a time. I wanna hear what your answers are, because I can't hear, I can't process some of this … So why, why does the air resistance affect the paper in a different way than the pen?

109. Khalid: Because this one is spreaded out.

110. Dave: Okay, so this one's spread out.

111. Khalid: The size … like … and the way the air hits it…

112. Dave: So is air resistance the only thing that makes the objects fall at the same rate?

113. Ron: The shape.

114. Dave: Okay so the shape has something to do with how things fall? Okay. Can you explain a little bit more? What do you mean by the shape?

115. Ron: The paper is kind of wide…

116. Dave: Janice, Ebony, can you stop talking please?

117. Ebony: We can. I didn't say we would, I just said we can.

118. Ron: The paper is wide … I think it's gonna bump into air particles or something…

119. Dave: Can you speak up a little bit?

120. Ron: The paper is wide right?

121. Dave: Right. The paper is spread out in space.

122. Ron: And doesn't it bump into like the air particles (inaudible)?

123. Dave: Okay yeah. So when the paper falls, it does bump into air particles, but so does … um … well let's look at the example. So, the bowling ball when it falls, it falls from the air particles too, right? And so does the rock, the rock bumps into air particles, too. But how come one's not slowed down more than the other.

124. Ron: The shape.

125. Dave: Because of the shape.

126. Ron: Yeah.

127. Dave: And so what does the shape do?

128. Ron: It just slows it down.

129. Dave: So why does the shape slow it down?

130. Ron: (*inaudible*)

131. Cortez: This is a lot of questions.

132. Dave: All right let's go on to number two. Let's go on to number two. Can I have a volunteer to read that one?

133. Khalid: Ooh!

134. Dave: Ebony, can you read number two for us please?

135. Ebony: "A bowling ball and a small rock are dropped from the same height at the same time. Which one lands first and this experiment is done … if this experiment is done? A) on the Earth."

136. Dave: Okay so let's look at the first one. So, will they fall—will they land at the same time if they're on the Earth. Two objects of different masses fall and land on the Earth.

137. Ebony: Yeah.

138. Dave: Okay. Okay so, because gravity causes all things to accelerate down at the same rate. So, what about on the Moon? Is there gravity on the Moon? Because the Moon's in outer space, right? Is there gravity on the Moon?

139. Students: No. No. Yes. No.

140. Dave: How many of you think there is gravity on the Moon, raise your hand. How many of you think that there's no gravity on the Moon?

141. (*Overlapping talk*)

142. Jada: There is on the Moon … it's just not a lot.

143. Dave: Sorry?

144. Jada: I said … wait … what was you saying?

145. Dave: So is there gravity on the Moon? Like, if you're on the Moon—if you're on the Moon, is there some kind of force that causes things to fall to the ground if you're on the Moon?

146. Tiara: Everything floats up there.

147. Anita: It's not a lot of it, like we have here.

148. Dave: So there's not a lot of gravity, right? But there is some.

149. Students: Some, yeah.

150. Dave: So on the Moon gravity does pull things down to its surface. But not as quickly as on Earth. On Earth things fall at about at 9.83 meters per second squared, right? But on the Moon it's only about 1.6 or 1.7. So instead of falling like that on the Moon things would accelerate much slower, on the Moon. So there is gravity on the Moon. But the Moon is very different from the Earth in that it doesn't have a whole lot of air on it, right? There's not a lot of air in the atmosphere. So, if you were to drop the bowling ball and the rock on the Moon, would they still both land at the same time? When there's very little air?

151. Students: Yes. No. Yes.

152. Dave: Yes. Okay why?

153. Quentin: Because, gravity would pull both of them together. Like, if there is no air, there is no air resisting. And they would pull at the same time.

154. Dave: Okay, all right. So, good. Okay so, as we're going through these questions, if there's stuff that you want to add to your responses, make sure you're filling that in. Um, okay let's look at number three. Can I get a volunteer? Willie, go ahead.

155. Willie: (*inaudible-reading question*) "Who is going to land first? The baby or the father?"

156. Dave: Okay, so the father who's obviously heavier, um, jumped out of the building at the same time that he throws the baby out of the building? So who's going to land first? Who's going to land first? (*Pause*) We've got a burning building. A father throws a baby out of a window and then at the same time that he throws the baby out of the window he jumps out. So they're both falling from the same height at the same time. Are they both gonna hit the ground at the same time? Or is the father going to hit the ground first? Or the baby gonna hit the ground first?

157. Janice: The baby gonna hit first.

158. Tiera: The baby.

159. Dave: Lemme get one at a time. Tiera.

160. Tiera: The baby.

161. Dave: The baby's gonna hit the ground first. Okay why?

162. Tiera: Because it was dropped first.

163. Dave: Sorry?

164. Tiera: The baby was dropped first.

165. Dave: Okay so we're saying that they both fall from the same height at the same time. So, it's kind of like, right as the father throws the baby out of the window, he also jumps out. So they're both…

166. Tiera: But he throws the baby out first.

167. Ebony: I thought they were gonna fall at the same time…

168. Tiera: So I thought the baby was gonna–

169. Dave: Okay. So if the father threw the baby out first and then jumped out after the baby, then yeah, the baby would probably hit first.

170. Khalid: That's what it said.

171. Dave: But I'm saying, what if they both jumped out at the same time?

172. Ebony: How you gonna throw the baby out and jump out at the same time?

173. Janice: Just…

174. Dave: Okay, so let's rephrase the question. Let's say that the, they're both standing on the window ledge okay, and they jump at the same time.

175. Ebony: First, how old is the baby?

176. Tiera and Janice: (*giggles*)

177. Dave: And they both jump at the same time. So then who's gonna fall into the catcher first?

178. Tiera: They both would fall into the catcher first.

179. Dave: At the same time?

180. Tiera: Right.

181. Dave: Even though the father, the father is heavier?

182. Ebony: Yeah.

183. Dave: Okay.

184. Ebony: So which one is that?

185. Dave: Number three

186. Ebony: And they gonna fall at the same time right?

187. Dave: What do you think?

188. Ebony: I said they gonna fall at the same time, so all that…

189. Girl: But it says "to escape the (*inaudible*) the father drops his baby."

190. Dave: Okay. So if you think they're gonna fall at the same time, why do you think they're gonna fall at the same time?

191. Ebony: 'cuz, everything on Earth gonna fall at the same time.

192. Janice: (*laughter*)

193. Tiera: They say he drop the baby out.

194. Ebony: If you drop 'em at the same time, they gonna fall at the same time.

195. Dave: Okay.

196. Tiera: Right, but he dropped 'em out first.

197. Ebony: Is that right?

198. Tiera: You all read the question wrong.

199. Ebony: (*inaudible*) man

200. Intercom: *BEEP BEEP BEEP BEEP*

201. Dave: Okay, number four. Look at number four. Who can rephrase the answer to number three? Or restate the answer to number three?

202. Ebony: Somebody needs to ‘cause I gotta write out the right thing.

203. Dave: Ebony, why don’t you go ahead and do it.

204. Ebony: Somebody else need to do it. All right I got mine. They gonna fall at the same time if they jump at the same time.

205. Tiera: (*cackles*)

206. Dave: All right. Number four. Number four. Bryant can you read number four for us, please.

207. Bryant: “Two identical plastic soda bottles, one of them full of soda, and the other completely empty are dropped from the roof of the school at the same time. A student, when asked which object lands first, answers as follows, ‘We learned from the Gal—’

208. Class: Galileo.

209. Bryant: ‘…experiments that all objects of different mass all fall at the same rate. So the full and empty bottle land at the same time.’ Do you agree, disagree, explain your reasoning.”

210. Dave: So what do you think? What if we actually did this experiment? We got up on the roof and we dropped an empty soda bottle and a full soda bottle at the same time. Would they both hit the ground at the same time?

211. Janice: No.

212. Boy: No.

213. Dave: Okay. Why not? Janice?

214. Tiera: Yes they would.

215. Janice: I think, it’s kind, this, uh, feels like, you know, the paper, when, when you had the paper, you drop it like this?

216. Dave: Uh huh.

217. Janice: It was like, sailing down slowly. Cuz the bottle doesn’t have anything in it but the other bottle does so it would, um, fall fast…

218. Dave: Okay, so the one, the bottle that's full of soda you're saying is gonna fall faster.

219. Janice: Uh huh.

220. Dave: Because it's what?

221. Janice: It has, uh more mass.

222. Dave: It has more mass. Okay. Tiera.

223. Tiera: But when you balled up the paper, and you drop the pen, and uh, the paper down at the same time, they both hit the uh thing at same time, even though the pen had more mass.

224. Dave: Right, so—okay, okay, so, from the Galileo experience, experiments, we know that when things fall when they are dropped from the same height, they should both hit the ground at the same time. But, you, intuitively know that if we actually did this experiment and dropped the soda bottles, the heavier one would hit first. So, so, how, how are, why are the Galileo experiments and then this experiment in conflict with each other? Why? What's going on? So what, what's affecting how the empty soda bottle falls?

225. Jada: Gravity.

226. Dave: Okay, gravity, that's true, gravity is pulling the soda bottle down.

227. Janice: Air resistance?

228. Dave: Anything else? Sorry.

229. Janice: Air resistance.

230. Dave: Air resistance. Okay, how does air resistance affect the soda bottle?

231. Janice: Because, um, like the paper is trying to go down and air resistance is pulling it up.

232. Dave: Okay, air resistance is-

233. Janice: Or slow it down.

234. Dave: Okay, how is air resistance slowing it down?

235. Janice: I don't know.

236. Dave: How does air resistance slow things down?

237. (*Multiple voices*)

238. Dave: Does it always slow lighter objects down?

239. Multiple voices: No.

240. Dave: Or what if, like what is necessary in order to slow down?

241. Ebony: No, it don't always, uh, do that to light things because if a fat person gets dropped, they fall real slow … Don't they?

242. Dave: Okay, if you drop—

243. Ebony: They don't just go down like a light person just go BOOM. They go like this (*floats slowly into her seat*).

244. Dave: So you're saying. Okay, so you're saying–

245. Ebony: But when they fall, you do know!

246. Dave: So you're saying thinner people fall faster than–

247. Ebony: Lighter people, mm hmm.

248. Dave: So, okay, so somebody just said, Janice said the heavier soda bottle is gonna fall first and Ebony just said that a lighter person would fall first than a heavier person. So those are two completely different ideas about the same things, right? Like, those are two completely different opinions about how objects fall given their weight. So, who's right?

249. Ebony: Me!

250. Boy: (*giggle*)

251. Dave: Okay, why are you right?

252. Ebony: I'm always right.

253. Dave: Really…

254. Ebony: Psyche, I don't know, I just think of that, I mean, 'cuz that's, because I, observe that, I see that, I have proof of that.

255. Dave: Really, okay. Where's your proof?

256. Ebony: Yeah! Ungh! Psst. Come on, Alvin, (*students laugh*) come on Shonte. Let me punch both of them and you tell me which one gonna fall first. (*laughs*) Who gonna fall faster and who gonna fall slower?

257. Dave: Is it, okay, is it possible that they would fall at the same rate?

258. Ebony: They not going to.

259. Dave: Why?

260. Ebony: Matter fact, they could if you hit 'em at the same time. With the same …l ike if you punch 'em with the same strength or might or whatever, they could fall at the same time. But I don't know, 'cuz I never seen that happen.

261. Dave: Okay, alright, let's keep it in the context of the soda bottle.

262. Ebony: Okay. If you know (*inaudible*)

263. Dave: We've got one soda bottle that's full and one that's empty. So—

264. Ebony: I think the lighter one gonna fall first.

265. Dave: Okay, why?

266. Ebony: I don't know.

267. Dave: So you're just guessing?

268. Ebony: Why don't you drink some soda here and you show us. You, you show us these things, you need to start showing us stuff so we could see the proof of it, because…

269. Dave: Okay. I don't have any soda bottles on me right now. But I want you to think what would happen if you did that. So why, why do you think the lighter soda bottle would fall first?

270. Ebony: Because it is lighter, so it has less stuff to hold while it's falling.

271. Dave: Less stuff to hold while it's falling.

272. Ebony: Yeah, it got less stuff, for you know what I'm saying, like, say like, psyche all right, this is lighter right? So watch this. (She drops two objects. Sounds of objects bouncing on the ground). That hit first. I mean that hit first. 'Cuz it don't have as much stuff in it to hold while its falling.

273. Dave: Okay so if you…

274. Ebony: It don't have as much stuff to take down with it.

275. Dave: So, you're saying that if something has more stuff to hold, then it's going to fall slower.

276. Ebony: Yeah.

277. Dave: —than something that isn't holding as much stuff. Okay. Janice.

278. Janice: Well, the lighter thing is gonna fall slower because the, um, bottle with, with, uh, the stuff in it, whatever, it has more mass, so it is easier to go through the air resistance. But since the bottle with nothing in it, it has like, this kind of, it takes a longer time to go through the air resistance.

279. Dave: Okay. So you're kind of saying that heavier objects, like when they are falling, they have more momentum to carry them through the air resistance.

280. Janice: Yes.

281. Dave: Whereas a lighter object–

282. Janice: Has to build it more.

283. Dave: Yeah, it doesn't have as much momentum, so it's going to be more affected by the air resistance?

284. Janice: Yeah.

285. Dave: Okay. So, that would mean that the, the heavier object in that case would fall faster.

286. Janice: It falls, yeah.

287. Dave: Okay. Alright, and let's look at number five.

288. Ebony: But you ain't never tell us the answer … what what what?

289. Dave: I want you to … Okay. I want you to put what you think is going to happen. So, you write down your answer, Janice, you write down your answer. Based upon … I mean—(*pause*). I want you to respond to these questions with your own reasoning. Why you think certain things are going to happen and then backing those, those responses up. Okay? (*Students write.*) Okay, number five. Allan, want to read this one?

290. Allan: (*reads the question*)

291. Dave: Okay. So what do you think's gonna happen? (*silence*) So the first ice cube reaches the bottom in one second. So is the bigger, heavier ice cube, going … released from the same position on the ramp going to reach the bottom in less than a second? At exactly one second? Or more than one second? What do you think?

292. Ebony: One second.

293. Dave: One second exactly?

294. Ron: One second exactly.

295. Ebony: Yeah.

296. Dave: Okay, so why?

297. Ebony: Cuz there's no friction.

298. Dave: Okay so you're saying that the bigger heavier ice cube is gonna hit the bottom at the same time as the smaller one.

299. Ebony: Yeah.

300. Dave: Because there's no friction.

301. Ebony: Yeah.

302. Janice: The ice is making it slippery.

303. Dave: Hmm?

304. Janice: Because the ice is making it slippery so it's, like she said it's got no friction.

305. Dave: Okay so the idea is that there is no friction, so…

306. Janice: Yeah.

307. Dave: Okay. So when we were talking, just, just a second ago, when we were talking about the heavier soda bottle falling faster than the lighter soda bottle. Okay, I want you to take that same concept and extend it to this question. So, if, if we kinda think that in the presence of air resistance, heavier objects will hit the

ground before lighter objects, then why doesn't the bigger heavier ice cube hit the bottom of the ramp before the smaller one?

308. Tiera: Because it's lighter.

309. Dave: Because it's … lighter?

310. Allan: Yessir.

311. Dave: Okay, all right. Let's take a poll. How many of you think it's gonna hit in less than one second? The bigger heavier one is going to get to the bottom of the ramp before the smaller one. How many think that, go ahead, raise your hands.

312. (*No one raises their hands*.)

313. Dave: Okay, how many people think that the bigger heavier ice cube is going to hit the bottom of the ramp before the smaller one? Okay. How many of you think that they're going to hit the bottom at the same time. Raise your hand.

314. (*Majority of class raises hands*.)

315. Dave: Okay, and how many of you think the bigger heavier ice cube is going to hit the bottom of the ramp in a longer amount of time than … after a longer amount of time than the first ice cube. Raise your hands. So those of you who said that the bigger heavier ice cube would hit the ground after the smaller ice cube, why do you think that? Because why?

316. Ron: Because it's got more water.

317. Dave: It's got more water?

318. Ron: Yeah, you know, you know when it goes down, you know how like it scrapes the ice and (*inaudible*)

319. Dave: Okay. So the idea is that we're trying to eliminate any kind of friction.

320. Ron: Oh, okay.

321. Dave: All right so we gotta wrap this up. Any last thoughts about the ice cube sliding down the ramp? All right so go ahead, put your name up at the top, period and the date, finish up any of your responses to the questions and then I want you to pass it up to the first person in each row.

322. (*Class talks and bell rings*.)

323. Dave: Okay, see you tomorrow, have a good day.