Does Classroom Time Matter?
A Randomized Field Experiment in Principles of Microeconomics

Ted Joyce
Baruch College, CUNY and NBER

Sean Crockett
Baruch College, CUNY

David A. Jaeger
CUNY Graduate Center, University of Cologne and NBER

Onur Altindag
CUNY Graduate Center

Stephen D. O'Connell
CUNY Graduate Center

August 2014

The authors thank participants at various seminars for helpful comments. Jaeger and Joyce acknowledge support from a CUNY Collaborative Incentive Research Grant (CIRG), Round 20. The project was approved by the CUNY Human Subject Protection Program on 29 April 2013 under Expedited Review Category 7. The corresponding author is Ted Joyce (Theodore.Joyce@baruch.cuny.edu)

Does Classroom Time Matter?
A Randomized Field Experiment in Principles of Microeconomics

Abstract

Little experimental evidence exists on the causal impact of class time on academic performance when students have access to extensive course material online. We randomized 725 college students into twice-per-week and once-per-week lecture formats in introductory microeconomics. Students in the traditional format scored approximately 3.2 out of 100 points better on the midterm but only 1.6 points better on the final. There were no differences in non-cognitive outcomes. Non-experimental estimates of the effect of attendance on test scores using our data are at least 2.5 times larger than experimental estimates, suggesting that previous estimates suffer from substantial selection bias. Our results suggest that the once-per-week lecture format offers savings in classroom time but at some cost to student performance.

James A. Garfield, twentieth president of the United States and a graduate of Williams College, is reputed once to have said of renowned educator Mark Hopkins: "the ideal college is Mark Hopkins on one end of a log and a student on the other" (Rudolf, 1956, p. vii). Garfield's epigram embodies the notion that the best learning takes place in a dialogue between student and professor, in which students take an active role in the learning process and professors can easily gauge a student's comprehension through verbal and non-verbal cues. This ideal remains at the core of American higher education despite the enormous changes in instructional technology that have occurred since the mid-19th century when Garfield was educated. In the mid 1950's, television was the first technology to capture the imagination of university administrators keen to reach a larger student population and, most importantly, hold the costs of instruction down (Macmitchell 1955; Eurich 1958). More recently, the Internet and various modes of online instruction have captured the imaginations of university administrators anxious to cut costs. Online learning in some form will surely be an increasingly important component of university education, even potentially improving on the kind of instruction Mark Hopkins might have offered to his students (Bowen, 2013).

To what extent does the opportunity to interact with a professor and other students matter in an environment rich in online materials? Recently, Figlio, Rush, and Yin (2013) compared students who took introductory economics online versus in a traditional lecture format at a major research university. Bowen, *et al.* (2014) examine the performance of students in an introductory statistics class held on six public university campuses, contrasting the performance of students attending a traditional class with two weekly meetings with those whose class material was delivered online supplemented by one weekly class meeting. Both studies reported

no overall difference in performance as measured by test grades between formats.[1] Participation rates in both studies were less than 25 percent, however, highlighting one difficulty of undertaking a classroom-based, semester-long randomized trial in a university setting.[2]

To gauge better the importance of classroom time in a typical "online rich" learning environment, we randomly assigned 725 students into "compressed" and traditional formats of introductory microeconomics at a large, urban, public university. We examine whether students who were offered class once a week for 75-minutes over a 14-week semester performed as well as students who were offered class twice per week, each for 75-minutes. Two experienced professors (the first two authors) taught four sections, one of each format. Students in the two formats had access to the same lecture slides, online material, and faculty-produced videos, which eliminated substitution bias as a source of attenuation since classroom time was the only difference between formats. Because research on student learning suggests that frequent assessments with immediate feedback improve performance (Pennebaker, Gosling and Ferrell 2013), we required students in both formats to take the online quizzes both before and after lectures, using a sophisticated interactive web application (Aplia) to deliver and grade them.

[1] Figlio, Rush, Yin (2013) did, however, find that Hispanic students and those with a grade point average below the median did less well in the online class.

[2] In addition to low participation rates, both studies encountered other difficulties. For example, Figlio, Rush, and Yin (2013) present results showing no mean differences in test scores between formats unadjusted for covariates but statistically significant differences of between 2 and 3 percentage points on a 100-point scale when adjusted. Students in the "live" format scored 3 percentage points higher on the final exam ($p<.05$) and 2.5 percentage points higher ($p<.01$) on the average of all three exams than students restricted to the video-taped lectures. See Table 3 in Figlio, Rush, and Yin (2013). The statistics experiment conducted by Bowen, *et al.* (2014) encountered difficulty coordinating test and grading across campuses and faculty – not all campuses used a common set of questions on the final and faculty, aware they were part of an experiment, may have graded more leniently in order to reduce failure rates.

We find that students in the traditional format performed 3.3 percentage points better on the midterm on a 100-point scale but a statistically insignificant 1.6 percentage points better on the final. The difference by format between the combined midterm and final was a statistically significant 2.3 percentage points. To put this result in perspective, if we divide this 2.3 point effect by the median difference in classes attended between formats, 11, then each extra class offered in the traditional format increased the final grade by 0.21 percentage points. Students in both formats attended the same proportion of classes, and there were no differences in withdrawal rates by format. We also find no difference in hours logged into Aplia or differences in the number of videos watched by class format. We further examine the impact of attendance on performance with a non-experimental subset of our data and find that the non-experimental estimates are between 2.5 and 4.5 times greater (in absolute value) than the experimental estimates, suggesting that non-randomized designs may significantly overstate the impact of attendance on learning outcomes.

Our results have meaningful pedagogical and administrative implications for undergraduate education. The fundamental difference in treatment between the traditional and compressed formats is the amount of time spent in the classroom, with students in the compressed sections having only half the amount of formal class time as those in the traditional sections. Our study can therefore be viewed as a strong test of whether substantial differences in attendance matter to academic performance when online materials are also available. We provide the first experimental evidence on the effects of attendance on academic performance. When we replicate the observational literature, we get very similar (and large) estimates of the effect of attendance. Our experimental estimates of the effect of attendance are smaller,

however, and indicate that the large effects in the previous literature are likely to be due to selection on unobservable characteristics.

I. The Experiment

Setting

The study took place at Baruch College, part of the City University of New York; as one the most diverse campuses in the country, the student body claims 163 nationalities and speaks 110 languages as of the 2013-2014 academic year.[3] Baruch's Zicklin School of Business is the largest accredited collegiate school of business in the country with 12,000 undergraduates. Almost all students commute to campus and most attend full-time.

Principles of Microeconomics (ECO 1001) is a required course for all students applying to the business program at Zicklin. It also fulfills a social science requirement for non-business majors. Nearly one thousand students take ECO 1001 each fall. Four sections with seats for a total of 776 students were part of our study, which accounted for 95% of the daytime non-honors seats available for the course.[4] Students could register for class on Mondays and Wednesdays in the morning or Tuesdays and Thursdays in the late afternoon. Classes were listed as taught by the first two authors of the study. Both are full-time, tenured faculty members who have taught

[3] Statistics about Baruch's student population are available from the authors upon request.
[4] Twenty-one seats went unfilled in the sections of the course in this study. Just over 100 students took ECO 1001 in the evening, most of whom were part-time students. Of the remaining students who were not part of our study, one section of 25 students was reserved for honors students only, and another daytime section of 40 students was taught by an adjunct faculty member.

the class for the past six years and both have strong teaching evaluations.[5] Registration for the fall classes began in April of 2013 and continued through August. Students currently enrolled in Baruch could register in April and May while transfer students from community colleges or other four-year colleges could not begin registration until June.

The Course

All sections of the class used N. Gregory Mankiw's *Principles of Microeconomics* (6th Edition) as the textbook, along with Cengage Learning's Aplia web application to administer and grade online quizzes. Each week students took a "pre-lecture quiz" due on Sundays and covering material to be taught in the upcoming week, and a "post-lecture quiz" due on Saturdays covering material that had been taught during the week. The pre-lecture quizzes were pass/fail (students who correctly answered at least half of the questions received full credit for the quiz) and were generally easier than the post-lecture quizzes; they were designed to ensure students came to lectures with some basic understanding of the material, without which the pace of the compressed lectures in particular would have been quite challenging for most students.

Lectures by professors formed the core of ECO 1001. During lectures, the professors presented microeconomic theory and examples using slides. The same slides were used in the compressed and traditional lectures by both professors, and were made available to all students for download, but they were covered more selectively and quickly in the compressed format, with less time to verbally annotate the slides, work through examples, and answer student

[5] Each professor has a rating of 4.3 based on teaching ECO 1001 on http://www.ratemyprofessors.com (last accessed February 3, 2014).

questions. There was also less time in the compressed format to go over difficult problems from the Aplia quizzes and to review practice questions for exams.[6] In addition, one of the professors recorded videos for each chapter from the text, in which he annotated answers to 10 multiple choice questions. Each video was approximately 30 minutes long but was broken up into segments ranging from 5 to 10 minutes each, so that students could easily select only the videos for which they sought explanations. The videos were taped in a studio with no audience but the lighting and sound were professionally supervised.

The compressed format forced the professors to compress lectures to fit the reduced class time, making the fundamental differences between the two formats a reduction in the amount of contact that students had with the professor (and classmates) and an increase in the pace of instruction during lectures. While other studies have tried to limit access to online material, this struck us as infeasible and a potential confounding factor for the results. All online content was available to students in both formats of the class in order to isolate the impact of classroom time on student performance. We believe the contrast between the two formats in our study is likely to be closer to the "real world" implementation of such courses.[7] Moreover, because classroom space and time are far more costly to provide than online materials, our treatment captures the relevant margin on which university administrators are likely to prefer one format over another.

[6] While several practice exams and solutions were made available to all students online, the traditional lecture format presented more opportunities to visit the practice exams during class.

[7] Any attempt to limit access to online course material among students in the traditional format would likely have failed. Moreover, there is a plethora of free online material for introductory microeconomics currently available.

Recruitment and Randomization

Recruitment began in May of 2013, shortly after the beginning of registration for the Fall 2013 semester. Students who had registered for one of the four class sections were sent an email inviting them to participate in the study with a link to the electronic consent form. The CUNY Institutional Review Board, in approving our application, allowed us to offer an incentive of five extra-credit points (out of 100) on their course average to students who participated in the study. For example, if a student's course average was 90 (an A-) the student's final numerical grade was increased to 95 (an A).[8] Students who chose not to participate were allowed to do an extra credit project for the same five points.[9]

Figure 1 depicts the flow of subjects in the experiment. Seven hundred and fifty-five students registered for the four sections of ECO 1001, of which 381 were in the Monday-Wednesday classes and 374 in the Tuesday-Thursday classes. Of the 755 registrants, 725 consented to be in the study, a 96% participation rate that represented 91 percent of all non-honors daytime students enrolled in ECO 1001. This participation rate is far greater than recent experimental studies of online learning. Thirty-two students either dropped the class before the

[8] Approximately 132 students in each treatment arm were necessary for a minimum detectable effect size of 4.2 percentage points with 90 percent power. Lowering power to 80 percent, the required sample sizes fell to 98 students in each treatment arm. By offering an incentive to participate, we expected to recruit most of the 776 students that were likely to register for the 4 experimental sections, allowing more than sufficient remaining sample even if withdrawal had been substantially greater than the 10 percent observed in the study. These five extra credit points indeed proved crucial to recruitment. The IRB also allowed us to offer a raffle in which 40 students picked randomly from the participants would be given priority registration for their classes in the spring of 2014. Comments from students suggested that the number of priority registrations was too few to be a significant incentive, but that the five extra-credit points for one of the 8 classes that determines admission to the business school was highly valued.

[9] Of the 26 non-participants who finished the course (two others withdrew and two did not take the final), only 11 (42%) completed the extra credit project.

midterm or did not take the midterm, and an additional 37 students took the midterm but afterwards either withdrew or did not take the final exam. The total post-randomization attrition rate was 9.5 percent.

We randomized students between formats within days (i.e. Monday-Wednesday or Tuesday-Thursday).[10] One section was taught in a large lecture hall that seats 274 students and the other section, taught at the same time, was in a classroom that held 114 students.[11] Each professor taught one compressed section and one traditional section, each in the same classroom. That is, Professor A taught a traditional section in the small classroom on Monday and Wednesday mornings and a compressed section in the same small room on Tuesday afternoons. Similarly, Professor B taught a traditional section in the large lecture hall on Tuesday and Thursday afternoons and the compressed section in the same room on Wednesday mornings. We can therefore control for the professor and classroom size fixed effects, but we cannot separately identify them. Moreover, the administratively imposed restriction of having different class sizes introduces a potential source of treatment heterogeneity. "Within professor" comparisons contrast students from different randomized samples and "within day" comparisons contrast performance across classroom/professor. We present several sets of results: the pooled sample of all students with controls for day and classroom/professor, comparisons within classroom/professor, and third, comparisons within day but across classroom/professor and course format.

[10] Students that registered for a Monday-Wednesday section could not be randomized into Tuesday-Thursday sections because it would have potentially created conflicts with other classes for which they had registered.

[11] For administrative reasons, we were unable to secure two large lecture halls during the same class period for the experimental sections given existing accommodation of other large lecture classes.

Outcomes

As with other experiments, our fundamental outcome measure is academic performance on exams and the final course grade. We administered both the midterm and final exams in class, and on both tests the same questions were used in all four sections. The midterm and final consisted of 30 and 40 multiple choice questions, respectively. The questions came both from a standardized test bank as well as being written by Professors A and B. A copy of each exam is included in the Appendix. As an overall measure of test performance, we summed the total number of correctly answered questions on the midterm and final and divided by 70, the total number of questions. We also present results with the overall course grade, in which the midterm and final exams counted for 35 and 45 percent, respectively. The remaining 20 percent of the course grade comprise online quizzes managed and graded by Aplia. The course grade also includes the penalty for missed classes described below, the five percentage-point bonus for participation, as well as curves for each exam.[12] In the results that we present below, we scale all test scores and the course grade so that they range from zero to 100. We prefer the combined exam score as a measure of academic performance because, unlike the course grade, it does not conflate non-cognitive (attendance) and cognitive (exams and online quizzes) outcomes.[13]

[12] Each exam was curved so that the median curved exam score was 80%. As a result of this curve, 2 points (out of 30) were added to each midterm score and 6 points (out of 40) were added to each final exam score in the calculation of course grades.

[13] Attendance is potentially endogenous and students could have worked with other students on their Aplia quizzes even for the questions that were algorithmically generated. Thus, the overall grade is a less-controlled measure of performance than the midterm and final exams.

The primary purpose of the Aplia quizzes was to encourage students to keep up with the material and improve their preparation for the lecture. They were not supervised (i.e. we cannot determine whether students did their own work or worked with other students) and were intended as low-stakes assessments. Except for the week in which the midterm was given, students had a pre-lecture quiz that was graded on a pass-fail basis with only one attempt at the correct answer, and a post-lecture quiz that was graded on the percent correct.[14] Students were permitted three attempts at the correct answer on the post-lecture quiz. In calculating the contribution of the Aplia quizzes to the final grade calculation, each quiz was weighted proportionately to its total possible points (on average, the post-lecture quizzes were worth about three times as many points as the pre-lecture quizzes), and for each student we dropped the pre-lecture quiz and post-lecture quiz that most adversely affected his or her grade.

In addition to students' cognitive performance, we also examine whether the different formats elicited different amounts of non-cognitive effort. First, we took attendance at every lecture. Students were required to swipe their student identification cards in a card reader within the first 15 minutes of class. The readers were linked to the registrar's database and the presence (or absence) of each student was verified and stored on a college server. Excluding the midterm and the first week of class, which did not count towards attendance requirements, students were allowed to miss 6 out of 25 lectures in the traditional format and three out of 12 in the compressed format without penalty, i.e. approximately 25 percent of the lectures. In the traditional classes, students lost one percentage point from their final grade for any late or missed classes beyond the six permitted absences, and in the compressed classes students lost two

[14] A student who answered at least 50% of the questions correctly on a pre-lecture quiz earned full points, while a student who answered less than 50% correctly received no adjustment. Thus 8 out of 15 correct was bumped up to 15/15, while 7 out of 15 was recorded as 7/15.

percentage points for any late or missed classes beyond the three permitted absences. The policy provided an incentive for students to swipe their ID cards, but it also created potentially meaningful variation in attendance within format.[15]

Second, we analyze withdrawal rates. We count as withdrawals students who enrolled in the class and consented to be in the study, but failed to finish.[16] We also measured withdrawals between the midterm to the final. Withdrawal rates are an important indicator of students' ability to manage a compressed format, but they also allow us to gauge the potential for attrition bias.

Third, for online content, we measured how many course videos the students watched. Because the videos were located all on one page in Blackboard for administrative reasons, we can only measure how many videos were watched and when, but not which videos. Lastly, In addition to quiz results, we measured the number of hours students spent logged in with Aplia.

II. Data

We combined several sources of data. All baseline characteristics were obtained from Baruch College's Office of Institutional Research and Program Assessment. These data included age, race/ethnicity, language spoken at home, major (if declared), grade point average

[15] Recitation sections, led by a graduate student, were held in conjunction with both large lectures. Each of the four recitations had a class size of almost 70 students. Attendance was voluntary, however, and extremely low. On average, students attended 1.1 recitations out of a possible 13 and the median and modal number of recitations attended was zero. There was no recitation available to students in the smaller classroom. Given the low participation rate, however, the presence of recitations should have little impact on the results.

[16] As noted, ECO 1001 is one of the eight classes that determine entrance to the Zicklin School of Business. Students can withdraw or not even show up for the final and accept a grade of F because they can retake the class and replace the F on their transcript. We treated official withdrawals and "no-shows" as the same.

(GPA), SAT scores, and cumulative credits. Some students have a GPA at Baruch, while transfer students have only GPA from their former college. Former transfer students have both GPAs. In the regression analysis, that follows, we include both GPAs and indicator variables for missing one or both of those GPAs.[17] We also do not have SAT scores for all students because not all transfer students were required to submit their SAT scores to Baruch. We also administered two short surveys in the first and last week of classes, soliciting students' attitudes toward compressed courses and whether they held any employment during the semester.

III. Results

Summary statistics and balance

Table 1 contains baseline characteristics of students by format in the pooled sample. Characteristics of students at the start of the experiment are shown in the left panel and characteristics at the end of the semester are shown in the right panel. Overall there is strong balance, with no statistically significant differences between traditional and compressed formats on any of the individual baseline characteristics in the beginning sample and only one statistically significant difference (age) between the formats among students who took the final exam. For both samples we estimated a logit with an indicator for assignment into the compressed format as the dependent variable and the previously described student characteristics

[17] We have a GPA measure for about 78% of our sample. Baruch accepts many transfer students, particularly from other CUNY schools, and an additional 15% of the sample has information on their GPA at the school from where they transferred. About 20% of our sample has both a GPA measure from Baruch and from their previous institution.

as the independent variables. The *p*-value for the overall χ^2 statistic from these regressions is 0.626 for the initial registrants and 0.157 in for the students who took the final exam. We also show the distribution of characteristics for the Monday-Wednesday and Tuesday-Thursday sections in Appendix Table 1 and these show similarly excellent balance.

Table 2 shows the baseline characteristics within professor/classroom. Estimating similar logit models as in Table 1 yields *p*-values that are larger than .05 for both the beginning and ending samples for Professor A and also in the beginning sample for Professor B, while in the ending sample for Professor B the differences are jointly significant at the 3.7% level. For both Professors, we do find some differences in the proportion of Asian students, who were more likely to register for Tuesday-Thursday sessions than Monday-Wednesday sessions. There are also some statistically significant differences in prior academic experience for the students randomized into the sections taught by Professor A. Recall that we could not randomize within professor/classroom because we could not randomize across the Monday-Wednesday and Tuesday-Thursday schedules as this would have caused conflicts with students' other scheduled classes, and student preferences for taking classes on different days or at a different time of day may lead to some small differences between the compressed and traditional groups for each professor. Overall, however, the balance within professor is excellent.

Performance On Tests and Quizzes: Pooled Sample

We show differences across formats in student performance on the midterm, final, the combination of both, Aplia quizzes, and the final course grade in Table 3. As noted above, we scale all results to range from 0 to 100 to facilitate comparisons across the various performance

metrics. For each outcome we show unadjusted (in odd-numbered columns) and adjusted (in even-numbered columns) mean percentage point differences. In all regressions in Table 3 we include an indicator for the Monday-Wednesday classes, although the coefficient on this variable is never statistically different from zero. Across all performance measures, we find that students in the compressed format did less well than students in the traditional format, and that these differences, except for Aplia scores, are statistically significantly different from zero. Adjusting for baseline covariates narrows the estimated mean differences between formats by a few tenths of one percentage point relative to the unadjusted differences. This similarity of the coefficient magnitudes in the unadjusted and adjusted specifications speaks to the balance in the pre-treatment covariates. The covariates also substantially increase the explanatory power of the model (increasing the R^2 from around one percent to 30 percent or more) and also yield moderate efficiency gains.

Our preferred measure is the combined midterm and final score (columns 7 and 8). We find that on average, students in the compressed format scored around 2.3 percentage points less than students in the traditional format, adjusted for covariates.[18] This 2.3 percentage point difference represents one fewer correct answer on a test of 40 questions. This effect is about .2 standard deviations of the mean score of students in the traditional sections. The lower bound of the 95 confidence interval from the estimated effect in column 8 is -4.2, approximately one half of a letter grade. The results were nearly identical for the overall course grade (columns 11 and 12).[19]

[18] The full output for the adjusted estimates is presented in Appendix Table 2. Students' GPAs and math SAT scores are, unsurprisingly, the primary predictors of class performance.

[19] Our results are similar to those of Figlio, Rush and Yin (2013) who reported that students in the live lecture of introductory economics scored a statistically significant 2.5 percentage points

Differences in test scores by format were larger for the midterm (columns 1 and 2) than the final (columns 5 and 6). Indeed, the adjusted differences between the final by format were 1.6 percentage points ($p.<0.14$) suggesting that students may have become more accustomed to the compressed format over the second half of the semester. We present results for the midterm for those students who completed the class in columns 3 and 4. The results are nearly identical to those in columns 1 and 2, suggesting that there is not selective attrition between the formats. This is confirmed in the results in Table 7 below, where we find no differences across format in the overall withdrawal rate or withdrawal after the midterm.

In Figure 2 we show kernel density estimates of all of outcomes in Table 3 for the compressed and traditional formats to examine visually differences in performance across formats. The red lines indicate the densities for the distribution of outcomes in the compressed sections while the blue lines indicate the distribution of outcomes in the traditional sections. The shaded area below each plot shows the difference in densities between traditional and compressed formats. The plots reveal a roughly symmetrical distribution of exam scores and the final grade, with the distribution in the compressed format shifted slightly left to that of the traditional distribution. The exception is the distribution of scores on the Aplia quizzes, which are nearly identical across formats (though clearly skewed left, reflecting that students were allowed three attempts to answer post-lecture quizzes correctly and some students failed to submit several assignments). We performed two-sample Kolmogorov-Smirnoff tests on the difference between the densities in each of the panels of Figure 2. We marginally rejected the

---

higher on the average of three exams relative to those in the online section, adjusted for covariates. Our point estimates are also within the 95 percent confidence intervals of the difference between scores obtained by students in the hybrid and traditional statistics classes studied by Bowen et al. (2013).

null hypothesis of equal densities only for the midterm, where the test had a *p*-value of 0.078. We also performed two-sample Kolmogorov-Smirnoff tests on the difference in the raw (unsmoothed) distribution between the compressed and traditional sections for all of the outcomes in Table 3, and rejected the null hypothesis of equal distribution for the midterm (p=.04), midterm plus final (p=.02), and the course grade (p=.096).

Performance On Tests and Quizzes Within Professor/Classroom

As noted earlier, we were unable to procure classrooms of equal size for administrative reasons. Each professor taught only in either a small classroom with a capacity of 114 students (Professor A) or in a large classroom with a capacity of 274 students (Professor B). Although we include professor/classroom fixed effects in Table 3, we cannot separately control for or distinguish between the effects of heterogeneous professors and classroom sizes.. To examine whether this is an issue, we present estimates of the treatment effects separately for each professor/classroom in Table 4. The top panel shows the results for Professor A (in the smaller lecture hall) while the bottom panel shows the results for Professor B (in the larger lecture hall). The outcomes are the same as in Table 3 and columns present unadjusted and adjusted treatment effects as in Table 3.

Overall, the results are quite consistent with those from the pooled sample shown in Table 3. Students in the compressed section taught in the large lecture hall (Professor B) scored approximately 3 percentage points lower on the combined midterm and final than students in the traditional class (lower panel, columns 5 and 6). Differences by format are somewhat less in the smaller classroom but are not as precisely estimated, reflecting the smaller sample size (upper

panel, columns 5 and 6). The estimated differences are also more sensitive to the inclusion of covariates than those in the pooled sample in Table 3. Recall that we only randomized within days. The within professor/classroom estimates therefore compare students from two different randomized samples. Although the balance of baseline characteristics by format appears reasonable, there are greater differences in some characteristics by format, as shown in Table 2. We view these results as being quite comparable to those from the pooled sample, however, while eliminating an important source of heterogeneity.

Performance on Tests and Quizzes Within Day

To illustrate the importance of professor/classroom heterogeneity, we show estimates of the compressed class time effect comparing formats within day in Table 5. The top panel (Monday-Wednesday) compares outcomes of students in which the compressed format was delivered in the large lecture hall and the traditional format in the smaller room. In the bottom panel (Tuesday-Thursday) the opposite occurred: students in the compressed format were in the smaller classroom and those in traditional format had class in the large lecture hall. The differences are striking. Students in the compressed format scored over 5 percentage points less on the combined midterm and final (top panel, columns 6 and 7) than those in the traditional class when the compressed was delivered in the large lecture hall, but there was no difference between formats when the compressed class was given in the smaller classroom (lower panel, columns 6 and 7). These differences are not likely due to imbalance between students in the two formats because randomization occurred within day (see Appendix Table 1). The results are at least suggestive that smaller class sizes may play an important role in learning. Students in

smaller classes meeting less frequently seem to perform about as well as students in larger classes that meets twice as often.

Performance On Tests: Interaction Effects

Our previous results would mask differences in performance for students with different characteristics if such parameter heterogeneity exists. In Table 6 we show the interaction effects of various student characteristics with the compressed indicator using the combined midterm and final score as the outcome.[20] For each model we include main effects for the compressed format and the characteristic of interest along with the Monday-Wednesday indicator. For models with covariates, we include the full set of covariates as employed in Table 3. Previous findings by Figlio, Rush and Yin (2013) suggest that that the performance of students with a higher baseline GPA may be less affected by the lecture format than weaker students who may need more interactive classroom time. In columns 1 and 2 we present unadjusted and adjusted effects for students in the upper half of the baseline GPA distribution.[21] Unlike Figlio, Rush, and Yin (2013), we find no evidence that low-GPA students perform worse in the compressed format.

[20] Results for the other test-based outcomes are similar and are available from the authors by request.

[21] We do not observe a GPA for new transfer students or for first year students. To create a single baseline GPA index, we regressed GPA on a quadratic in transfer GPA, a quadratic in age, the number of cumulative credits, an indicator for female, and an indicator for being an underclassman for the 158 students for whom we observe both (transfer students who have been at Baruch at least one semester). We use this predicted GPA for students with only a transfer GPA. Our predicted GPA has a correlation of .504 with the actual GPA within the sample of 158 students who have both. Non-transfer first year students will have neither a transfer GPA or a GPA, and for these observations (n=34) we include a dummy variable for missing GPA.

We do not find any differences in being in the compressed by sex (columns 3 and 4) or race (columns 5 and 6). Given that students in both formats have access to online materials, we might expect that non-native English speakers would find it more difficult to keep up with the faster learning tempo in the compressed format. But here we also find no difference in effects of being in the compressed format (columns 7 and 8).

Students who work may prefer the flexibility of having fewer class hours to attend. In columns 9 and 10 we find relatively large, but imprecisely estimated, negative effects of being in the compressed for working students. This suggests that although working students may find the compressed more convenient, fewer class hours also translate into fewer hours spent learning overall, which manifests itself in poorer performance. In our data, students who worked spent somewhat less time watching videos and working on Aplia as students do did not work. Students who worked more than 30 hours per week were also less likely to attend class.[22]

Attendance, Online Usage, Attrition, and Other Classes

In addition to test scores, we also examine the effect of being in the compressed format on a variety of non-cognitive outcomes related to effort. In Table 7 we present the impact of the compressed format on attendance, the number of videos watched, time spent online using Aplia, the probability of withdrawing from the class at any time, and the probability of withdrawing from the class after the midterm. Columns 1 and 2 show that there is no difference between the formats in the average proportion of classes attended. We do find, however, that students in the

[22] We also estimated models similar to those in Table 7 below with attendance and online usage as the outcomes, but with the compressed indicator interacted with working. Although rarely statistically significant the estimated coefficients on the interaction terms were usually negative.

smaller classroom taught by Professor A were somewhat more likely to attend and that students that had the morning Monday-Wednesday lectures were 2.2 percentage points less likely to attend than those with in the late afternoon Tuesday-Thursday lectures. We should note, however, that 17 percent of students in the compressed class were penalized for excessive absences, relative to 9 percent in the traditional format.

In column 3 we show that students in the compressed format had 1.8 more video views than students in the traditional format relative to a mean of 8.5 views. It is noteworthy that when we add the professor/classroom fixed effect (and other covariates) in column 7, we find that students whose professor was in the videos watch the videos 8.6 more times than those whose professor was not in the videos. Students appear drawn to videos in which *their* professor appears rather than an unknown "talking head." The finding argues for personalizing online material as much as possible. We find no differences in the number of hours students spent on Aplia (columns 5 and 6), although students spent a substantial amount of time on Aplia. The mean was 44 hours or about 3.1 hours per week over 14 weeks. Although the result is not statistically significant, there appears to be some evidence that students in Professor A's classes substituted time watching videos for time on Aplia. Overall, student effort as measured by attendance, videos, and online quizzes was largely the same by format. Importantly, students in the compressed format did not appear to substitute more use of the measurable online material for reduced time they spent in the classroom. While it is possible, of course, that students in the compressed format spent more time studying the textbook or with other online materials that we do not measure, we suspect that reducing time in class leads to a decrease in the total amount of time that students were engaged with ECO 1001 relative to those in the traditional format.

The lack of differences in attendance and intensity of online usage by format indicates that students in the compressed class had, on average, a minimum of 13.8 more hours during the semester to apply to other material related ECO 1001 or to their other courses.[23] As a check we tested for variation in student grades in the other classes taken in the same semester with ECO 1001 by format but found no differences across students in different formats of ECO 1001.[24] In columns 7 and 8 we present results indicating that students did not withdraw more at any time from the class in the compressed sections and in columns 9 and 10 we find the same result for withdrawal after the midterm. These findings indicate that attrition bias is unlikely to affect our results.

Student Surveys: Preference for Compressed or Traditional

We surveyed students in the first and last week of classes about their preferences regarding class formats. In the first week of class, we asked students to rate the statement, "I would have chosen the hybrid over the traditional format if I had had the choice," on a four-point Likert scale ranging from "Strongly Agree" to "Strongly Disagree".[25] The students exhibited a strong *a priori* preference for the compressed format, but it varied by their random (but known) assignment: 78 percent of those randomly assigned to the compressed format agreed or strongly agreed, but only 55 percent in the traditional format did. When we asked students at the end of the semester (but prior to the final exam or knowing their final grade) if they would chose the same format for their next economics class, the results shifted in favor of the traditional format:

[23] The difference in the median number of classes attended between the two formats was 11, and each class period was 75 minutes. This figure does not include time getting to and from class.
[24] These results are available from the authors by request.
[25] We referred to the compressed format as a "hybrid" format in the student surveys.

65 percent of the students in the traditional class but only 54 percent in the compressed format agreed or strongly agreed. Thus, the preference for the traditional format increased by 20 percentage points from the beginning of the semester amongst those in the traditional format, while the preference for the compressed format decreased by 24 percentage points among those in the compressed format. Despite this change in preferences, 67 percent of students in the traditional format and 62 percent in the compressed format agreed or strongly agreed that having class twice per week helped their grade, but 62 percent students in the compressed format disagreed with the statement that the compressed format hurt their grade. Somewhat surprisingly, we found no differences in responses when we stratified the data by the students' baseline GPA. We interpret the survey results to mean that students found the compressed format appealing before having experienced it, but found it challenging during the semester. We thus expect that a substantial proportion of students would not opt for the compressed format for their next economics class.

IV. Comparison with Observational Estimates of the Effect of Attendance

Our fundamental experimental manipulation was to randomly assign the number of classes that students could attend. The experimental treatment limited students in the compressed to at most 13 classes, inducing a difference in the median number of classes attended to 11, i.e. traditional format students attended nearly twice as many classes as those in the

compressed format.[26] Because all of the other inputs (textbook, lecture slides, online content, office hours, etc.) were identical between the two formats, this provides a strong test of the effects of attendance on academic performance and is, to our knowledge, the first such experimental evidence. Although the induced change in attendance may seem quite large, numerous non-experimental studies have used differences in attendance of 50 to 75 percent to quantify effects of attendance on student performance (Romer, 1993; Devadoss and Foltz, 1996; Kirby and McElroy, 2003; Cohn and Johnson, 2003). In these studies, the researchers extrapolated the marginal impact of class attendance on student performance, adjusted for student characteristics.

To contrast our experimental estimates of the effects of attendance on performance with those from non-experimental studies, in Table 8 we present results where we regress student performance on the final exam on the number of classes attended.[27] Although we had a mandatory attendance policy, there was no penalty for missing up to six lectures in the traditional format, and there is still substantial variation in attendance. Among those students in the traditional format who took the final exam, the median number of classes attended was 22, the minimum was 2, and the standard deviation was 3.1. In columns 1 and 2 we present observational estimates of the effect of attendance, using only students in the traditional format. In column 1 we do not adjust for any student characteristics and estimate that each missed class

[26] We permitted any student in the compressed sections to attend traditional classes if they asked. Five students chose to do so. For these students the percent of classes attended could exceed 100 percent.

[27] We present results using only the final exam here because, unlike the simple compressed vs. traditional comparison, other outcome measures may suffer from greater endogeneity bias. For example, students may endogenously adjust their attendance after doing poorly on the midterm. The final grade measure explicitly includes attendance as part of the grade. The results for the midterm+final and class grade are very similar to those presented here for the final exam, however, and are available from the authors by request.

results in a score that is 1.23 percentage points lower on the final exam. In column 2, we include the same set of control variables as in Table 3, except that instead of separately entering Baruch GPA and Transfer GPA, we include as a summary measure the Predicted Baruch GPA measure used in Table 6. Not surprisingly, the point estimate drops substantially -- here we estimate that each missed class costs the student 0.58 percentage points on their final exam score. These estimates are of course vulnerable to the same omitted variable problems as any observational study.

The estimate in column 2 is very close to results in the observational literature on class attendance. Romer (1993) found that an increase in attendance from 25 to 100 percent would increase performance in an introductory economics class by a full grade. Devadoss and Foltz (1996) also reported that a 50 percent increase in attendance would boost a student's performance by a full grade in various agricultural economics classes. Kirby and McElroy (2003) estimated that students who increased attendance at tutorials from zero to the mean of 62 percent would improve their grade by 13 percentage points while Cohen and Johnson (2003) report that students missing 50 percent of classes reduced students' scores by 4.3 percentage points. More recently, Dobkin, Gil and Marion (2010) used a regression discontinuity design to compare the performance of students who scored just below the median on the midterm, and who were required to attend all subsequent classes, to students who scored just above the median on the midterm for whom attendance remained voluntary. Assuming effects are linear, they found that mandatory attendance after the midterm increased the final test score by 0.17 standard deviations for every 10 percentage point increase in attendance. To make our results comparable to these magnitudes, note that the standard deviation on the final exam in the traditional format was 5.9 and that a 10 percent increase in classes would be 2.5 classes. Therefore, increasing

attendance by 10 percent would lead to an increase in the score on the final of 1.45 percentage points, or 0.23 standard deviations. Overall our non-experimental estimate of the association between attendance and performance is consistent with the previous observational literature. Online material for introductory economics posted for the class, but also available from the Internet more generally, may lessen the importance of class attendance as compared to 10 to 20 years ago.

We contrast our non-experimental estimates with the experimental estimates for the final exam using the compressed indicator as an instrument for classes attended. Recall that, on average, students in the traditional sections attend 11.0 more classes than those in the compressed format sections and that the difference in average score on the final exam was 2.27, yielding a Wald estimate of the effect of attendance on final exam performance of 0.206 percentage points.[28] We control for the Monday-Wednesday indicator in column 3, yielding a return to attendance of 0.22 percentage points and add the other covariates (as in column 2) in column 4, giving a return to attendance of 0.13 percentage points. The last row shows the coefficient on the compressed indicator in the first-stage regressions. The second-stage estimates of the returns to attendance are comparable to our results columns 5 and 6 in Table 3 and are *substantially* smaller than those in columns 1 and 2, suggesting that the non-experimental estimates are biased upwards even after controlling for GPA, SAT scores, and cumulative credits.

[28] Specifically: $\frac{\bar{F}_T - \bar{F}_C}{\bar{A}_T - \bar{A}_C} = \frac{60.985 - 58.716}{21.255 - 10.244} = \frac{2.269}{11.011} = .206$, where F is the percentage correct on the final exam, A indicates number of lectures attended, T indicates the traditional sections, and H indicates the compressed sections.

These results come with three caveats. First, the non-experimental extrapolations (including ours) all assume a linear effect of attendance on performance. The effect may be concave, however, with smaller marginal increases in performance as more classes are attended. Second, our required weekly pre-quizzes and post-quizzes may have reduced the gains from class attendance relative to studies without such course requirements, since our students had an incentive to interact with the material regularly even in the event of missed classes. Third, we assume that attending one less class each week in the compressed format is the equivalent to missing one lecture in a course structured to present material over two lectures. This also may not hold completely. To give a concrete example, consider a chapter on perfect competition. In the traditional class, the first lecture of the week may cover short-run profit maximization and derivation of the short-run supply curve. In the second lecture of the week, students are exposed to the dynamics of competition and long-run equilibrium. In the compressed format we attempted to touch on all four topics in one lecture.

V. Conclusion

We found that students in a traditional lecture format of introductory microeconomics, with twice as much face-to-face instruction, performed better than students in a compressed version of the same class. The difference was equivalent to one question in a 40-question exam. However, we found no difference by format when students in the compressed class in a classroom of 114 seats were compared to students in the traditional format in a lecture hall that has 272 seats. We also uncovered no differential effects by GPA or for those who are native English speakers, but suggestive evidence that students in the compressed format who worked

did less well than their working counterparts in the traditional format. Lastly, we demonstrated that previous estimates of the positive effect of attendance on class performance are likely biased upwards because of omitted variables related to diligence, organization and motivation.

We have improved on the existing literature in several important dimensions. First, we had a 96 percent participation rate and an attrition rate of 10 percent that did not vary across experimental treatments, strongly supporting a claim to internal validity. Second, each of the two participating faculty taught one of each format, which allowed us to control for a potential source of heterogeneity. Third, all students had access to the same lecture notes and online materials, eliminating an artificial and arguably unenforceable restriction of access to online materials for students in the traditional class. Lastly, our large sample, with 725 students at the beginning of the experiment and 656 at completion, allowed us a great degree of precision in our estimates.

Fifty percent of participants in the study were transfer students to Baruch, 21 percent from community colleges within the City University of New York system—a population similar to that in Bowen et al. (2013).[29] Our results are also relevant to recent studies of online instruction at community colleges, because the vast majority of students at Baruch also commute (Jaggars and Xu, 2011; Xu and Jaggars, 2013).[30] Overall, we are most comfortable suggesting that our findings are likely to pertain to large urban public universities in which a substantial proportion of students commute and/or work.

[29] Indeed Baruch College was one of the six sites in the study by Bowen et al. (2013).

[30] Xu and Jaggars (2013) reported that community college students scored a full grade lower in courses delivered completely online relative to their counterparts who took courses in a traditional face-to-face environment. Differences in performance by format were much smaller in our study, which is further evidence that purely online courses may be more challenging for students that commute and/or work.

The compressed format was not costly to produce. Sophisticated testing software along with e-textbooks used in large introductory undergraduate classes are available from numerous publishers for less than the cost of a traditional textbook. Faculty can assign frequent homework and quizzes as well as provide students with additional practice problems, videos and whiteboard supplements. Much of the skill building of basic concepts can be done outside of the classroom, preserving class time for clarification of more complex concepts. The potential gains in faculty productivity as measured by faculty compensation per student, as well as better use of limited classroom space, are obvious sources of savings for large introductory classes traditionally delivered twice a week in a limited number of lecture halls with multiple small-group recitations. Bowen et al. (2013) estimate savings from a compressed class based on labor costs alone to be between 36 and 57 percent. While clearly more work on cost and savings from compressed formats is needed, we are confident that our findings are relevant for introductory classes in the natural sciences, mathematics, statistics, and other social sciences.

References

Bowen, William G. 2013. *Higher Education in the Digital Age* (Princeton, NJ: Princeton University Press).

Bowen, William G., Matthew M. Chingos, Kelly A. Lack, Thomas I. Nygren. 2014. "Interactive Learning Online at Public Universities: Evidence from a Six-Campus Randomized Trial," *Journal of Public Policy Analysis and Management* 33(1): 94-111.

Figlio, David, Mark Rush, and Lu Yin. 2013. "Is it Live or Is It Internet? Experimental Estimates of the Effects of Online Instruction on Student Learning," *Journal of Labor Economics* 31(4): 763-784.

Cohn, Elchanan. and Johnson Eric. 2006. "Class Attendance and Performance in Principles of Economics,"*Education Economics* 14(2): 211-233.

Collins, Ellaine D. 2013. "SJSU Plus Augmented Online Learning Environment Pilot Project Report." The Research & Planning Group for California Community Colleges, 2013. http://www.sjsu.edu/chemistry/People/Faculty/Collins_Research_Page/AOLE%20Report%20-September%2010%202013%20final.pdf (last accessed 16 February 2014).

Devadoss, Stephen and John Foltz. 1996. "Evaluation of factors influencing student class attendance and performance," *American Journal of Agriculture Economics* 78(3): 499-507.

Dobkin, Carlos, Gil, Ricard, and Justin Marion. 2010. "Skipping Class in College and Exam Performance: Evidence from a Regression Discontinuity Classroom Experiment," *Economics of Education Review* 29(4): 566-575.

Eurich, Alvin C. 1958. "A Foundation Looks at College Teaching by Television," *Journal of Educational Sociology* 31 (9):329-336.

Ho, Andrew Dean, Justin Reich, Sergiy O Nesterko, Daniel Thomas Seaton, Tommy Mullaney, Jim Waldo and Iasaac Chung. 2014. "HarvardX and MITx: The First Year of Open Online Courses, Fall 2012-Summer 2013. SSRN, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2381263 (last accessed 27 February 2014).

Jaggars, Shanna Smith and Di Xu. 2011. "Online and Compressed Course Enrollment and Performance in Washington State Community and Technical Colleges," Community College Research Center Working Paper Number 31, Teachers College, Columbia University, March.

Kirby, Ann and Brendan McElroy. 2003. "Does Attendance Affect Grade? An Analysis of First Year Economics Students in Ireland," *Economic and Social Review* 34(3): 311–326.

Lewin, Tamar. 2013. "After Setbacks Online Courses Are Rethought." *New York Times*, December 10. http://www.nytimes.com/2013/12/11/us/after-setbacks-online-courses-are-rethought.html (last accessed 16 February 2014).

Macmitchell, Leslie T 1955. "Are Institutions Planning Ahead?" *The Journal of Higher Education* 26 (9): 463-469+504.

Mankiw, N. Gregory. 2012. *Principles of Microeconomics 6th* (Mason, Ohio: South-Western).

Pennebaker, James W., Goslings, Samuel D. and Jason D. Ferrell. 2013. "Daily Online Testing in Large Classes: Boosting College Performance while Reducing Achievement Gaps," PLoS ONE 8(11): e79774. doi:10.1371/journal.pone.0079774

Romer, David. 1993. "Do Student Go to Class? Should They?" *Journal of Economic Perspectives* 7(3): 167-174.

Rudolf, Frederick. 1956. *Mark Hopkins and the Log: Williams College 1836-1872* (New Haven, CT: Yale University Press).

U.S. Department of Education. 2010. *Evaluation of Evidence-Based Practices in Online Learning: A Meta-Anlysis and Review of Online Learning Studies*, Washington, D.C. http://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf (last accessed 16 February 2014).

Xu, Di, and Shanna Smith Jaggars. 2011. "The Effectiveness of Distance Education Across Virginia's Community Colleges: Evidence From Introductory College-Level Math and English Courses," *Educational Evaluation and Policy Analysis* 33: 360-377

Xu, Di, and Shanna Smith Jaggars. 2013. "The Impact of Online Learning on Students' Course Outcomes: Evidence from a Large Community and Technical College System," *Economics of Education Review* 37: 46-57

Figure 1
Flowchart of Student Intake and Random Assignment

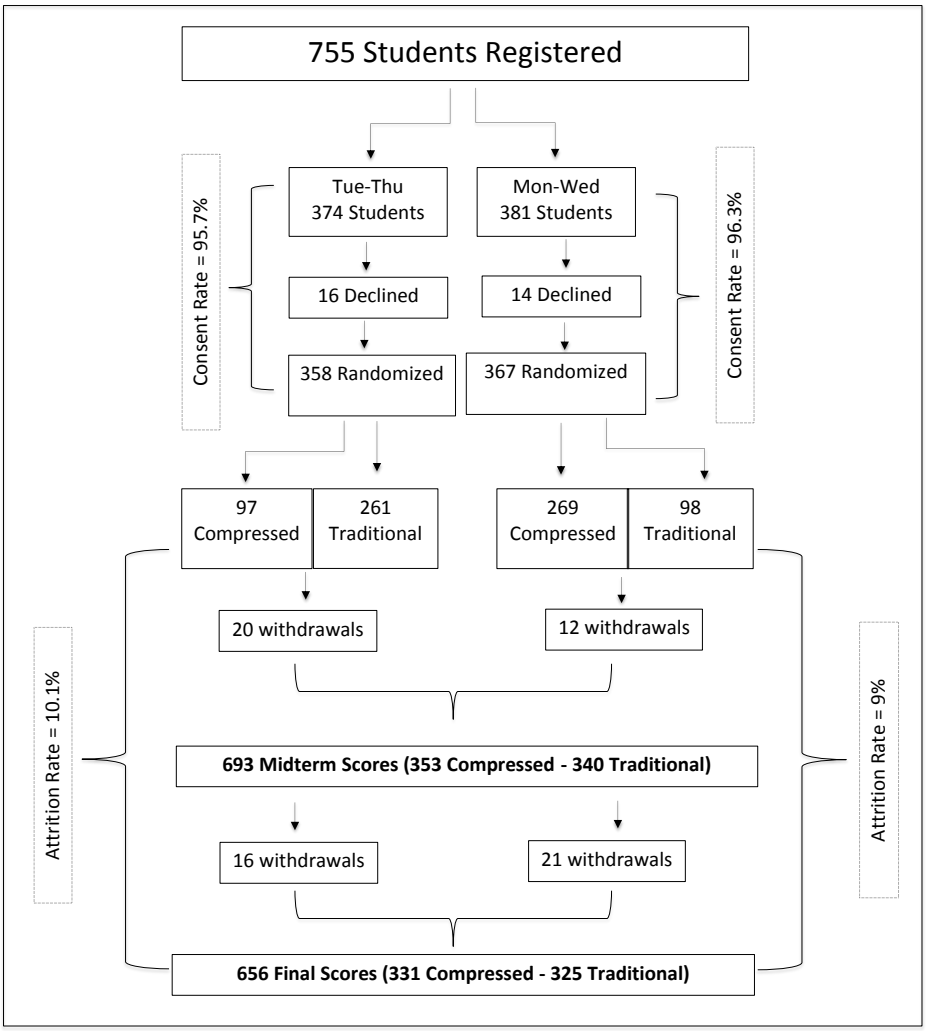


Figure 2
Kernel Density Estimates of Student Performance

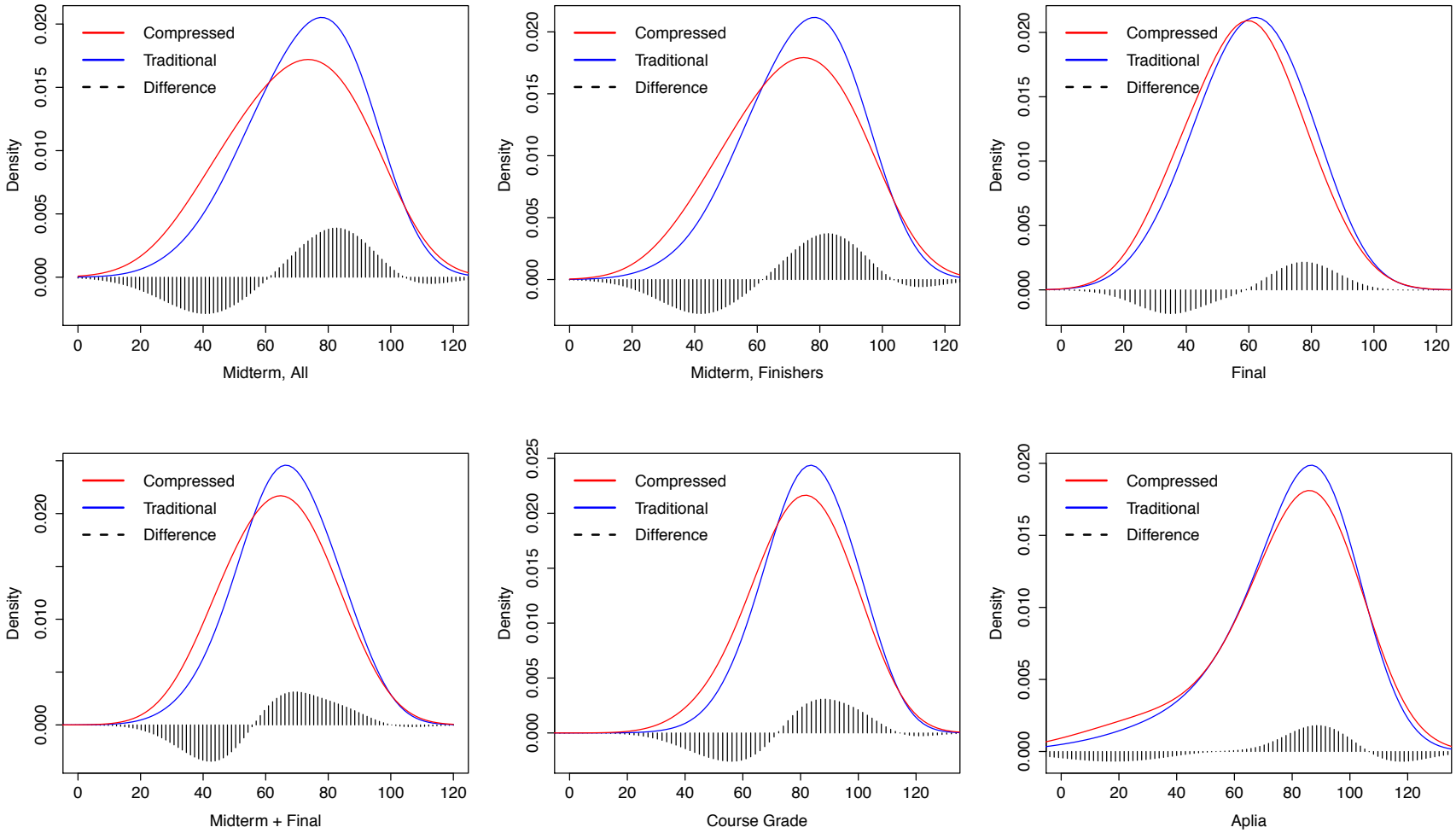


Table 1
Baseline Characteristics of Participants at the Beginning and End of the Semester

	Beginning Sample				Ending Sample			
Covariate	**Traditional**	**Compressed**	**Compressed - Traditional**	***N***	**Traditional**	**Compressed**	**Compressed - Traditional**	***N***
Prior Academic Performance								
Baruch GPA	3,00	3,01	0,01	568	3,01	3,06	0,05	518
Transfer GPA	3,31	3,26	-0,05	265	3,34	3,28	-0,06	230
SAT Verbal	541,56	533,31	-8,25	556	544,71	537,12	-7,60	511
SAT Math	601,90	596,17	-5,73	556	607,42	600,94	-6,48	511
Prior Academic Experience								
Cumulative Credits	45,93	44,98	-0,95	725	45,24	43,96	-1,28	656
Underclass	0,73	0,77	0,04	725	0,74	0,79	0,05	656
Attends Part Time	0,08	0,07	-0,00	725	0,08	0,07	-0,02	656
Demographic Characteristics								
Age	21,22	20,93	-0,30	725	21,23	20,70	-0,53 **	656
Female	0,45	0,48	0,02	725	0,44	0,46	0,02	656
Asian	0,44	0,43	-0,02	606	0,46	0,44	-0,03	546
Black, Hispanic, Other	0,31	0,28	-0,03	606	0,29	0,26	-0,03	546
Native English Speaker	0,54	0,53	-0,02	621	0,53	0,53	0,00	561
p-value, joint χ^2-test		0,626				0,157		

Note: Statistical significance tested using two-sample *t*-tests assuming unequal variances. Significance levels are indicated by * <.10, ** <.05, *** <.01. The joint χ^2 tests are based on logit regressions of Comprssed on all variables shown in the table plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race/Ethnicity, and Native English Speaker. Sample size for left panel is 725, sample size for right panel is 656.

Table 2
Baseline Characteristics of Participants at the Beginning and End of the Semester
by Professor / Classroom Size

	Beginning Sample				Ending Sample			
Covariate	**Traditional**	**Compressed**	**Compressed - Traditional**	***N***	**Traditional**	**Compressed**	**Comp.- Trad.**	***N***
				Professor A / Small Classroom				
Prior Academic Performance								
Baruch GPA	3.06	2.89	-0.18	143	3.08	2.95	-0.13	131
Transfer GPA	3.37	3.32	-0.05	71	3.42	3.31	-0.11	65
SAT Verbal	543.52	520.67	-22.85	146	545.61	520.14	-25.47	138
SAT Math	609.01	594.53	-14.48	146	614.39	596.11	-18.28	138
Prior Academic Experience								
Cumulative Credits	48.80	42.58	-6.22 *	195	47.94	41.87	-6.08 *	181
Underclass	0.67	0.81	0.14 **	195	0.70	0.82	0.12 *	181
Part time	0.11	0.05	-0.06	195	0.12	0.04	-0.07 *	181
Demographic Characteristics								
Age	21.26	20.89	-0.37	195	21.27	20.67	-0.60	181
Female	0.48	0.48	0.00	195	0.48	0.47	-0.01	181
Asian	0.36	0.58	0.22 ***	160	0.39	0.58	0.19 **	148
Black, Hispanic, Other	0.30	0.18	-0.12 *	160	0.26	0.17	-0.09	148
Native English Speaker	0.54	0.51	-0.03	171	0.52	0.50	-0.02	161
p-value, joint χ^2-test		0.126				0.221		
				Professor B / Large Classroom				
Prior Academic Performance								
Baruch GPA	2.98	3.05	0.08	425	2.98	3.10	0.11 *	443
Transfer GPA	3.29	3.23	-0.06	194	3.31	3.26	-0.05	157
SAT Verbal	540.86	537.78	-3.08	410	544.38	543.38	-1.00	373
SAT Math	599.34	596.75	-2.60	410	604.83	602.72	-2.11	373
Prior Academic Experience								
Cumulative Credits	44.85	45.84	0.99	530	44.17	44.73	0.56	475
Underclass	0.75	0.75	0.01	530	0.75	0.78	0.03	475
Part time	0.07	0.08	0.02	530	0.07	0.07	0.01	475
Demographic Characteristics								
Age	21.21	20.94	-0.27	530	21.22	20.71	-0.50 *	475
Female	0.44	0.47	0.03	530	0.43	0.45	0.03	475
Asian	0.48	0.38	-0.10 **	446	0.49	0.39	-0.10 **	398
Black, Hispanic, Other	0.31	0.31	-0.00	446	0.29	0.30	0.01	398
Native English Speaker	0.54	0.53	-0.01	450	0.53	0.54	0.01	400
p-value, joint χ^2-test		0.167				0.038		

Note: Statistical significance means between traditional (lectures twice per week) and compressed (lectures once per week) tested using two-sample *t*-tests assuming unequal variances. Significance levels are indicated by * <.10, ** <.05, *** <.01. The joint χ^2 tests are based on logit regressions of Compressed on all variables shown in the table plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race/Ethnicity, and Native English Speaker. Sample sizes are 195 (beginning) and 181 (ending) for the top panel and 530 (beginning) and 475 (ending) for the bottom panel.

Table 3
Student Performance

	Midterm, All		Midterm, Finishers		Final		Midterm + Final		Aplia		Course Grade	
Covariate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Compressed	-3,77 ***	-3,24 ***	-3,30 **	-3,26 ***	-2,42 *	-1,64	-2,80 **	-2,33 **	-0,99	-1,28	-2,86 **	-2,59 ***
	(1,45)	(1,16)	(1,43)	(1,16)	(1,32)	(1,10)	(1,24)	(0,97)	(1,75)	(1,48)	(1,24)	(0,96)
Mon.-Wed.	<.0.01	-1,09	0,23	-0,87	0,34	-1,02	0,29	-0,96	-1,50	-2,06	-0,03	-1,20
	(1,45)	(1,18)	(1,43)	(1,19)	(1,32)	(1,11)	(1,24)	(0,98)	(1,74)	(1,55)	(1,24)	(0,97)
Prof. A/Small Class		3,67 ***		2,78 ***		3,14 ***		2,98 ***		1,60		2,70 ***
		(1,14)		(1,14)		(1,10)		(0,95)		(1,56)		(0,96)
Other covariates		X		X		X		X		X		X
R^2	0,013	0,383	0,010	0,378	0,006	0,325	0,010	0,429	0,003	0,311	0,010	0,457
N	693		656		656		656		656		656	
Mean score, Trad.	73,17		74,16		60,98		66,63		78,66		82,93	
Standard Dev., Trad.	15,54		14,93		14,85		13,08		19,20		13,11	

Note: All outcomes are based on a 100-point scale. Estimated with OLS. Heteroskedasticity-consistent standard errors in parentheses. Significance levels are indicated by * <.10, ** <.05, *** <.01. Other covariates are Baruch GPA, Transfer, GPA, Verbal SAT, Math SAT, Cumulative Credits, Age, indicator variables for Part-Time Student, Underclassman, Female, Asian, Black/Hispanic/Other, and Native Speaker plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race, and Native English Speaker. Mean scores are for students in the traditional format. Midterm, Final, and Midterm+Final are raw (uncurved) scores. Aplia is average score on online quizzes. Course Grade includes curved midterm and final grades, penalties for missed classes, and the 5 percentage point participation bonus.

Table 4
Student Performance within Professor / Classroom

	Midterm, All		Final		Midterm + Final		Aplia		Course Grade	
Covariate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					Professor A / Small Classroom					
Compressed	-3,71	-2,82	-2,69	-0,28	-3,01	-1,33	0,57	0,24	-2,76	-1,57
	(2,46)	(2,19)	(2,23)	(2,05)	(2,13)	(1,85)	(2,92)	(2,47)	(2,12)	(1,77)
Other covariates		X		X		X		X		X
R^2	0,012	0,460	0,008	0,415	0,011	0,490	<0.001	0,338	0,009	0,503
N	184		181		181		181		181	
Mean score, Trad.	76,16		63,61		69,13		79,34		85,11	
Std. Dev., Trad.	16,01		14,51		13,91		21,21		13,96	
					Professor B / Large Classroom					
Compressed	-3,70 **	-4,50 ***	-2,04	-2,62 **	-2,47 **	-3,39 ***	-2,47	-3,38 **	-2,86 **	-3,87 ***
	(1,48)	(1,22)	(1,37)	(1,22)	(1,23)	(1,00)	(1,90)	(1,64)	(1,27)	(1,00)
Other covariates		X		X		X		X		X
R^2	0,012	0,365	0,005	0,302	0,008	0,417	0,004	0,338	0,011	0,459
N	509		475		475		475		475	
Mean score, Trad.	72,04		59,95		65,65		78,39		82,07	
Std. Dev., Trad.	14,51		14,89		12,64		18,39		12,69	

Note: All outcomes are based on a 100-point scale. Estimated with OLS. Heteroskedasticity-consistent standard errors in parentheses. Significance levels are indicated by * <.10, ** <.05, *** <.01. Other covariates are Baruch GPA, Transfer, GPA, Verbal SAT, Math SAT, Cumulative Credits, Age, indicator variables for Part-Time Student, Underclassman, Female, Asian, Black/Hispanic/Other, and Native Speaker plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race/Ethnicity, and Native English Speaker. Mean scores are for students in the traditional format. Midterm, Final, and Midterm+Final are raw (uncurved) scores. Aplia is average score on online quizzes. Course Grade includes curved midterm and final grades, penalties for missed classes, and the 5 percentage point participation bonus. Capacity of the small classroom is 114 students whle the large classroom is 274 students.

Table 5
Student Performance within Class Day

	Midterm, All		Final		Midterm + Final		Aplia		Course Grade	
Covariate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					Monday - Wednesday Classes					
Compressed	-7,83 ***	-6,83 ***	-5,71 ***	-4,46 ***	-5,95 ***	-5,05 ***	-3,42	-2,51	-5,90 ***	-4,96 ***
	(2,00)	(1,57)	(1,79)	(1,40)	(1,71)	(1,25)	(2,65)	(2,24)	(1,74)	(1,25)
Other Covariates		X		X		X		X		X
R^2	0,037	0,434	0,029	0,409	0,035	0,495	0,005	0,365	0,032	0,524
N	355		334		334		334		334	
Mean Score, Trad.	76,16		63,61		69,13		79,34		85,11	
Std. Dev., Trad.	16,01		14,51		13,91		21,21		13,96	
					Tuesday-Thursday Classes					
Compressed	0,42	1,07	0,98	1,62	0,47	0,85	1,53	1,22	0,28	0,49
	(2,05)	(1,78)	(1,91)	(1,78)	(1,76)	(1,55)	(2,25)	(2,05)	(1,75)	(1,53)
Other Covariates		X		X		X		X		X
R^2	<0.001	0,340	0,001	0,298	<0.001	0,386	0,001	0,288	<0.001	0,404
N	338		322		322		322		322	
Mean Score, Trad.	72,04		59,95		65,65		78,39		82,07	
Std. Dev., Trad.	16,01		14,89		12,64		18,39		12,69	

Note: All outcomes are based on a 100-point scale. Estimated with OLS. Heteroskedasticity-consistent standard errors in parentheses. Significance levels are indicated by * <.10, ** <.05, *** <.01. Other covariates are Baruch GPA, Transfer, GPA, Verbal SAT, Math SAT, Cumulative Credits, Age, indicator variables for Part-Time Student, Underclassman, Female, Asian, Black/Hispanic/Other, and Native Speaker plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race, and Native English Speaker. Mean scores are for students in the traditional format. Midterm, Final, and Midterm+Final are raw (uncurved) scores. Aplia is average score on online quizzes. Course Grade includes curved midterm and final grades, penalties for missed classes, and the 5 percentage point participation bonus.

Table 6
Interaction Effects on the Combined Midterm and Final

Grade Point Average			**Sex**			**Race and Ethnicity**			**Native English Speaker?**			**Hours Worked Per Week**		
Category	(1)	(2)	**Category**	(3)	(4)	**Category**	(5)	(6)	**Category**	(7)	(8)	**Category**	(9)	(10)
< Median	ref.		Male	ref.		White	ref.		No	ref.		None	ref.	
≥ Median	-0.49	-0.75	Female	-0.01	0.74	Asian	3.76	0.34	Yes	2.62	2.06	1-30 hrs	-4.30	-2.44
	(1.97)	(1.73)		(2.14)	(1.68)		(2.77)	(2.14)		(2.38)	(1.83)		(2.66)	(2.01)
						Black/	1.66	-0.09				> 30 hrs	-5.86	-2.73
						Hisp./Oth.	(3.08)	(2.38)					(4.18)	(3.50)
Missing	1.85	1.35				Missing	2.35	-1.50	Missing	-0.84	-3.22	Missing	-0.56	-1.81
	(4.35)	(3.96)					(3.64)	(2.81)		(2.91)	(2.43)		(4.12)	(3.54)
Covariates		X	Covariates		X	Covariates		X	Covariates		X	Covariates		X
p for joint χ^2	0.855	0.814				*p* for joint χ^2	0.587	0.922	*p* for joint χ^2	0.380	0.066	*p* for joint χ^2	0.284	0.669
R^2	0.223	0.436	R^2	0.032	0.429	R^2	0.052	0.430	R^2	0.019	0.433	R^2	0.075	0.444

Note: Outcome is the combined midterm plus final scaled to 100 points. Estimated with OLS. Heteroskedasticity-consistent standard errors in parentheses. Significance levels are indicated by * <.10, ** <.05, *** <.01. Coefficients reported are for the interaction with Hybrid of the indicated category. All regressions also include a main effect for Compressed and for the indicated categories. All regressions include a dummy variable for Monday-Wednesday class meeting and a main effect for Comprssed. Regressions with covariates include, where appropriate Baruch GPA, Transfer, GPA, Verbal SAT, Math SAT, Cumulative Credits, Age, indicator variables for Part-Time Student, Underclassman, Female, Asian, Black/Hispanic/Other, and Native Speaker plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race, and Native English Speaker. The reported *p*-values are from χ^2 tests that the reported interactions with Comprssed are jointly equal to zero. The sample size for each regression is 656. In columns (1) and (2) the measure used to stratify is the median of Baruch GPA/Predicted Baruch GPA. We use the Baruch GPA for students who have one, and predicted Baruch GPA for students who do not have Baruch GPA, but have a Transfer GPA. Predicted Baruch GPA is calculated from a regression of Baruch GPA on a quadratic in Transfer GPA, a quadratic in Age, Cumulative Credits, and indicators variables for Female and Underclassman for the 148 students who have both a Baruch GPA and a Transfer GPA. There are 51 students who have neither a Baruch GPA nor a Predicted Baruch GPA.

Table 7
Attendance, Attrition, and Online Usage

	Percentage Attended		Number of Videos		Hours on Aplia		Withdrew Any Time		Withdrew After Midterm	
Covariate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Compressed	1.21	0.98	1.82	2.52 *	0.45	0.29	0.007	0.005	0.016	0.009
	(1.11)	(1.11)	(1.76)	(1.50)	(2.48)	(2.19)	(1.425)	(0.023)	(0.015)	(0.016)
Mon.-Wed.	-1.91	-2.23 **	-0.16	-0.65	2.91	3.34	-0.014	-0.015	0.004	0.012
	(1.11)	(1.12)	(1.75)	(1.56)	(2.47)	(2.32)	(0.023)	(0.023)	(0.015)	(0.014)
Prof. A/Small Class		2.03 *		8.58 ***		-2.07		-0.034		-0.053 ***
		(1.09)		(1.60)		(2.34)		(0.024)		(0.015)
Other covariates		X		X		X		X		X
R^2	0.004	0.104	0.003	0.177	0.003	0.182	<0.001	0.069	0.002	0.065
N	656		656		656		725		693	
Mean Outcome, Trad.	85.02		8.54		44.26		0.095		0.044	
Std. Dev., Trad.	12.46		12.46		27.64		0.293		0.206	

Note: Estimated with OLS. Heteroskedasticity-consistent standard errors in parentheses. Significance levels are indicated by * <.10, ** <.05, *** <.01. Percentage Attended is on a 100-point scale. Other covariates are Baruch GPA, Transfer, GPA, Verbal SAT, Math SAT, Cumulative Credits, Age, indicator variables for Part-Time Student, Underclassman, Female, Asian, Black/Hispanic/Other, and Native Speaker plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race, and Native English Speaker. Mean outcomes are for students in the traditional format. 69 students in total withdrew at any time during the course, and 27 withdraw after the midterm. Withdrawal after the midterm is conditional on having taken the midterm.

Table 8
Non-Experimental and Experimental Estimates of Student Performance on Final Exam

	Observational		Experimental	
	(OLS)	(OLS)	(IV)	(IV)
Covariate	(1)	(2)	(3)	(4)
Number of Classes Attended	1,23 ***	0,58 ***	0,22 *	0,13
	(0,23)	(0,21)	(0,12)	(0,10)
Monday-Wednesday			0,39	-0,91
			(1,32)	(1,09)
Prof. A/Small Class		2,82 *		3,47 ***
		(1,45)		(1,07)
Baruch GPA/		11,38 ***		10,96 ***
Predicted Baruch GPA		(1,31)		(0,94)
Verbal SAT/100		1,34		1,07
		(1,11)		(0,75)
Math SAT/100		2,66 **		3,75 ***
		(1,27)		(0,85)
Other Covariates		X		X
R^2	0,067	0,381	0,021	0,337
N	325		656	
Mean outcome	60,98		59,84	
Std. Dev. of outcome	14,85		15,07	
First Stage IV: Dependent Varaible Number of Classes Attended				
Hybrid			-10,92 ***	-10,90 ***
			(0,22)	(0,21)

Note: Outcome is based on a 100-point scale. Heteroskedasticity-consistent standard errors in parentheses. Significance levels are indicated by * <.10, ** <.05, *** <.01. Other covariates are Cumulative Credits, Age, indicator variables for Part-Time Student, Underclassman, Female, Asian, Black/Hispanic/Other, and Native Speaker plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race, and Native English Speaker. Predicted Baruch GPA is calculated from a regression of Baruch GPA on a quadratic in Transfer GPA, a quadratic in Age, Cumulative Credits, and indicators variables for Female and Underclassman for the 148 students who have both a Baruch GPA and a Transfer GPA. There are 51 students who have neither a Baruch GPA nor a Predicted Baruch GPA.

Appendix Table 1
Baseline Characteristics of Participants at the Beginning and End of the Semester by Instruction Day

	Beginning Sample				Ending Sample			
Covariate	**Traditional**	**Compressed**	**Compressed - Traditional**	***N***	**Traditional**	**Compressed**	**Compressed - Traditional**	***N***
				Monday-Wednesday				
Prior Academic Performance								
Baruch GPA	3.06	3.05	-0.01	286	3.08	3.10	0.02	260
Transfer GPA	3.37	3.23	-0.14	127	3.42	3.26	-0.16 *	109
SAT Verbal	543.52	537.78	-5.74	283	545.61	543.38	-2.22	138
SAT Math	609.01	596.75	-12.27	283	614.39	602.72	-11.68	138
Prior Academic Experience								
Cumulative Credits	48.80	45.84	-2.96	367	47.94	44.73	-3.22	334
Underclass	0.67	0.75	0.08	367	0.70	0.78	0.08	334
Part time	0.11	0.08	-0.03	367	0.12	0.07	-0.05	334
Demographic Characteristics								
Age	21.26	20.94	-0.33	367	21.27	20.71	-0.56	334
Female	0.48	0.47	-0.01	367	0.48	0.45	-0.02	334
Asian	0.36	0.38	0.01	315	0.39	0.39	-0.00	286
Black, Hispanic, Other	0.30	0.31	0.00	315	0.26	0.30	0.04	286
Native English Speaker	0.54	0.53	-0.01	317	0.52	0.54	0.02	286
p-value, joint χ^2-test		0.551				0.450		
				Tuesday-Thursday				
Prior Academic Performance								
Baruch GPA	2.98	2.89	-0.09	282	2.98	2.95	-0.03	258
Transfer GPA	3.29	3.32	0.03	138	3.31	3.31	0.01	121
SAT Verbal	540.86	520.67	-20.19	273	544.38	520.14	-24.24 *	250
SAT Math	599.34	594.53	-4.81	273	604.83	596.11	-8.72	250
Prior Academic Experience								
Cumulative Credits	44.85	42.58	-2.28	358	44.17	41.87	-2.30	322
Underclass	0.75	0.81	0.07	358	0.75	0.82	0.07	322
Part time	0.07	0.05	-0.01	358	0.07	0.04	-0.02	322
Demographic Characteristics								
Age	21.21	20.89	-0.31	358	21.22	20.67	-0.54	475
Female	0.44	0.48	0.04	358	0.43	0.47	0.04	475
Asian	0.48	0.58	0.11	291	0.49	0.58	0.09	398
Black, Hispanic, Other	0.31	0.18	-0.13 **	291	0.29	0.17	-0.12 **	398
Native English Speaker	0.54	0.51	-0.03	304	0.53	0.50	-0.03	400
p-value, joint χ^2-test		0.366				0.080		

Note: Statistical significance means between traditional (lectures twice per week) and hybrid (lectures once per week) tested using two-sample *t*-tests assuming unequal variances. Significance levels are indicated by * <.10, ** <.05, *** <.01. The joint χ^2 tests are based on logit regressions of Compressed on all variables shown in the table plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race/Ethnicity, and Native English Speaker. Sample sizes are 367 (beginning) and 334 (ending) for the top panel and 358 (beginning) and 322 (ending) for the bottom panel.

Appendix Table 2
Regression Coefficients for Student Outcomes, Table 3

Outcome:	**Midterm, All**		**Midterm, Finishers**		**Final**		**Midterm + Final**		**Aplia**		**Course Grade**	
Table 3 Column:	**(2)**		**(4)**		**(6)**		**(8)**		**(10)**		**(12)**	
Covariate	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**
Compressed	-3,238	1,159	-3,263	1,155	-1,636	1,101	-2,334	0,968	-1,276	1,476	-2,587	0,957
Monday-Wednesday	-1,088	1,181	-0,871	1,186	-1,019	1,114	-0,955	0,978	-2,056	1,546	-1,201	0,973
Professor A/Small Classroom	3,670	1,142	2,776	1,140	3,138	1,100	2,983	0,954	1,600	1,562	2,696	0,959
Verbal SAT/100	0,354	0,713	0,173	0,696	1,102	0,804	0,704	0,644	-1,830	1,011	0,169	0,632
Math SAT/100	6,494	0,803	6,148	0,824	3,896	0,859	4,861	0,721	2,949	1,162	4,442	0,722
Missing SAT scores	-4,035	1,861	-3,607	1,841	0,862	1,860	-1,053	1,596	0,796	2,261	-0,771	1,563
Baruch GPA	11,187	1,099	11,456	1,123	10,323	1,001	10,809	0,909	17,476	1,669	12,816	0,981
Missing Baruch GPA	2,188	1,551	2,996	1,568	2,238	1,603	2,563	1,357	4,885	1,869	3,275	1,315
Transfer GPA	9,542	2,441	7,895	2,388	7,257	2,613	7,530	2,126	8,665	2,713	7,662	1,910
Missing Transfer GPA	-0,517	1,728	-0,530	1,702	2,419	1,816	1,155	1,476	-2,086	2,467	0,364	1,482
Cumulative Credits	-0,023	0,044	-0,017	0,045	-0,040	0,042	-0,030	0,036	-0,229	0,062	-0,068	0,036
Underclassman	-1,796	2,116	-1,398	2,157	-2,355	2,121	-1,945	1,769	-6,786	2,765	-2,838	1,701
Part time	-2,793	2,569	-2,622	2,582	1,186	2,179	-0,446	2,099	-5,128	3,537	-1,220	2,176
Age	-0,372	0,262	-0,377	0,282	0,062	0,220	-0,126	0,214	0,436	0,268	-0,006	0,192
Female	-2,625	1,071	-3,166	1,053	-4,130	1,022	-3,717	0,862	-1,129	1,390	-3,112	0,852
Asian	-1,309	1,417	-0,988	1,410	-0,320	1,341	-0,606	1,119	0,431	1,897	-0,520	1,103
Black/Hispanic/Other	-1,926	1,596	-1,614	1,565	-1,241	1,462	-1,401	1,252	-3,820	2,159	-2,283	1,279
Missing Race	2,658	1,773	2,552	1,808	1,594	1,811	2,005	1,505	2,087	2,433	1,674	1,479
Native English Speaker	-0,070	1,223	0,059	1,207	-2,192	1,174	-1,227	1,003	-0,169	1,706	-1,088	1,008
Missing Language	0,885	1,576	-0,431	1,612	-2,297	1,539	-1,498	1,277	-2,118	1,979	-1,646	1,245
Constant	-20,679	10,714	-12,576	10,455	-20,953	11,740	-17,363	9,671	-2,184	13,771	-1,834	9,043
R^2	0,383		0,378		0,325		0,429		0,311		0,457	
N	693		656		656		656		656		656	

Note: All outcomes are based on a 100-point scale. Estimated with OLS. Heteroskedasticity-consistent standard errors. Course Grade includes curved midterm and final grades, penalties for missed classes, and the 5 percentage point participation bonus.

Appendix: Midterm and Final Exams

The same exams, with questions randomly ordered, were given in both formats.

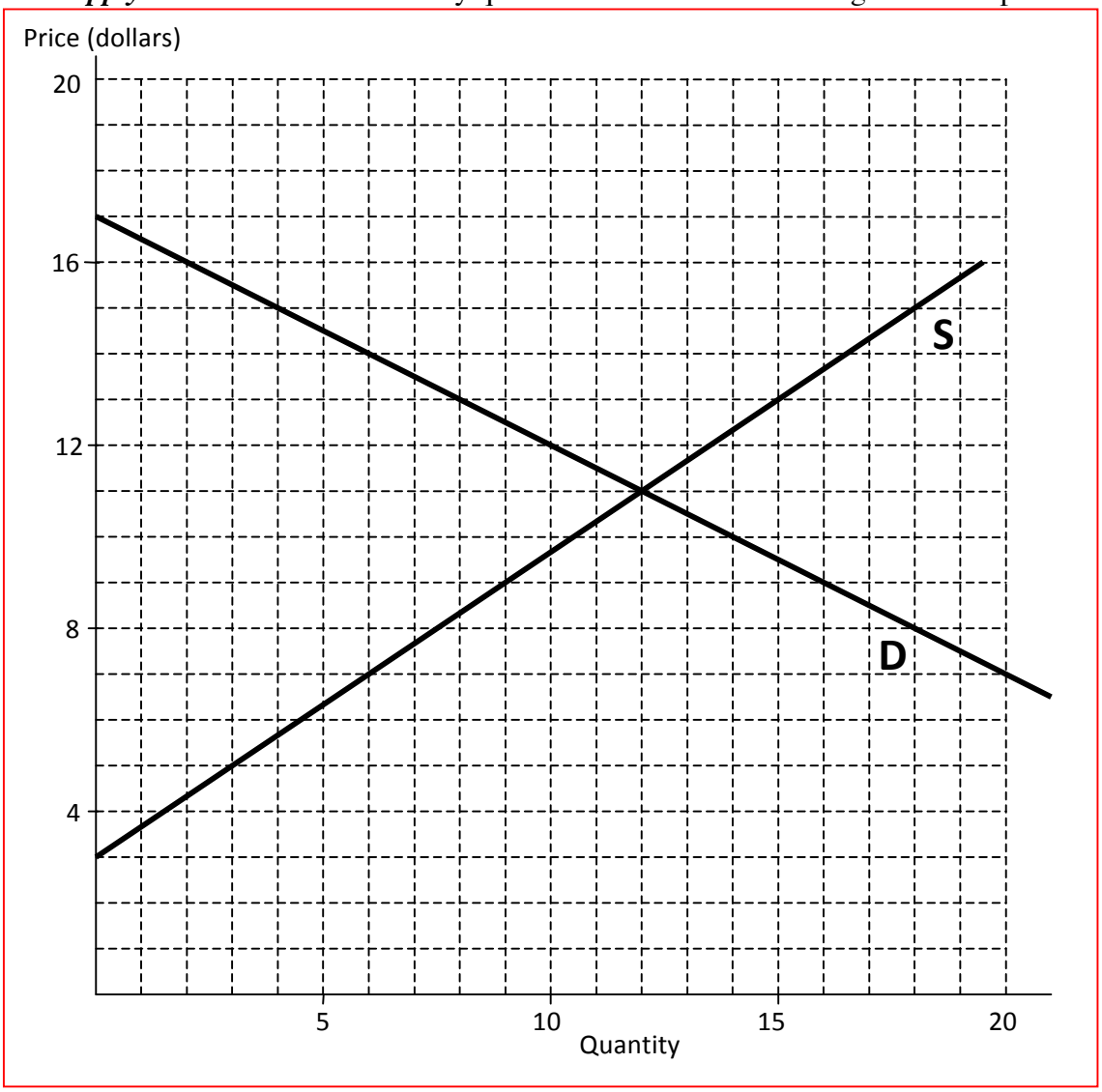
Name:_____ **Class:**_____ **Date:** _____ **ID: A**

Exam 1 Fall 2013-14

Multiple Choice

Identify the letter of the choice that best completes the statement or answers the question.

Figure: Supply and Demand. Treat every question that references this figure as independent.



1. **Refer to *Figure: Supply and Demand***. If a price floor of $13 is imposed on this market, what is the likely effect?

a. A surplus of 7 units
b. A shortage of 7 units
c. A surplus of 5 units
d. Nothing, the price floor is not binding.

2. **Refer to *Figure: Supply and Demand***. What is consumer surplus in equilibrium?
a. $24
b. $36
c. $48
d. $72

3. **Refer to *Figure: Supply and Demand***. If there is a $7 per unit negative externality associated with the consumption of this good, what is total surplus after the socially optimal tax is implemented?
a. $21
b. $36
c. $42
d. $54

4. **Refer to *Figure: Supply and Demand***. How much tax revenue is generated by a $7 per unit tax?
a. $28
b. $35
c. $42
d. $49

Table: Production. Assume that the farmer and the rancher can switch between producing meat and producing potatoes at a constant rate.

	Labor Hours Needed to Make 1 Pound of		Pounds Produced in 24 Hours	
	Meat	Potatoes	Meat	Potatoes
Farmer	8	2	3	12
Rancher	3	6	8	4

5. **Refer to *Table: Production***. Assume that the farmer and the rancher each have 24 labor hours available. If each person divides his time equally between the production of meat and potatoes, then total production is
a. 3 pounds of meat and 12 pounds of potatoes.
b. 5.5 pounds of meat and 8 pounds of potatoes.
c. 8 pounds of meat and 4 pounds of potatoes.
d. 11 pounds of meat and 16 pounds of potatoes.

6. **Refer to *Table: Production.*** Which of the following statements is correct?
a. The farmer has an absolute advantage in potato production but a comparative advantage in meat production.
b. The farmer has an absolute advantage in meat production but a comparative advantage in potato production.
c. The farmer has both an absolute advantage and comparative advantage in meat production.
d. The farmer has both an absolute advantage and comparative advantage in potato production.

Table: Willingness to Pay

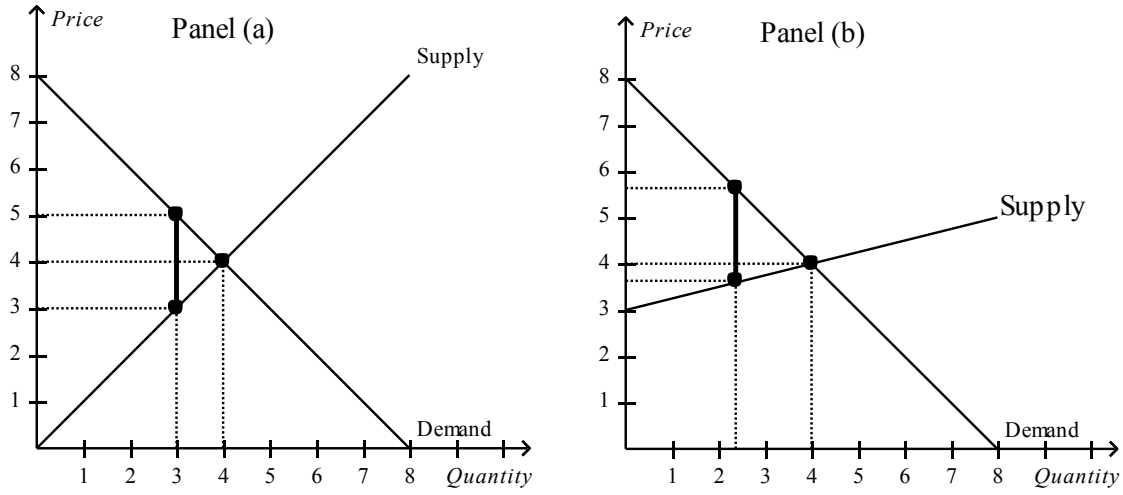
Consider the town of Anywhere with only three residents, Mary, Bill, and Tricia. The three residents are trying to determine how large, in acres, they should build the public park. The table below shows each resident's willingness to pay for each acre of the park.

Acres	Mary	Bill	Tricia
1	$14	$18	$30
2	10	14	26
3	6	10	22
4	4	6	18
5	2	3	14
6	0	1	10
7	0	0	6

7. **Refer to *Table: Willingness to Pay*.** Suppose the cost to build the park is $33 per acre. How many acres maximizes total surplus from the park in Anywhere?

a. 2 acres
b. 3 acres
c. 4 acres
d. 5 acres

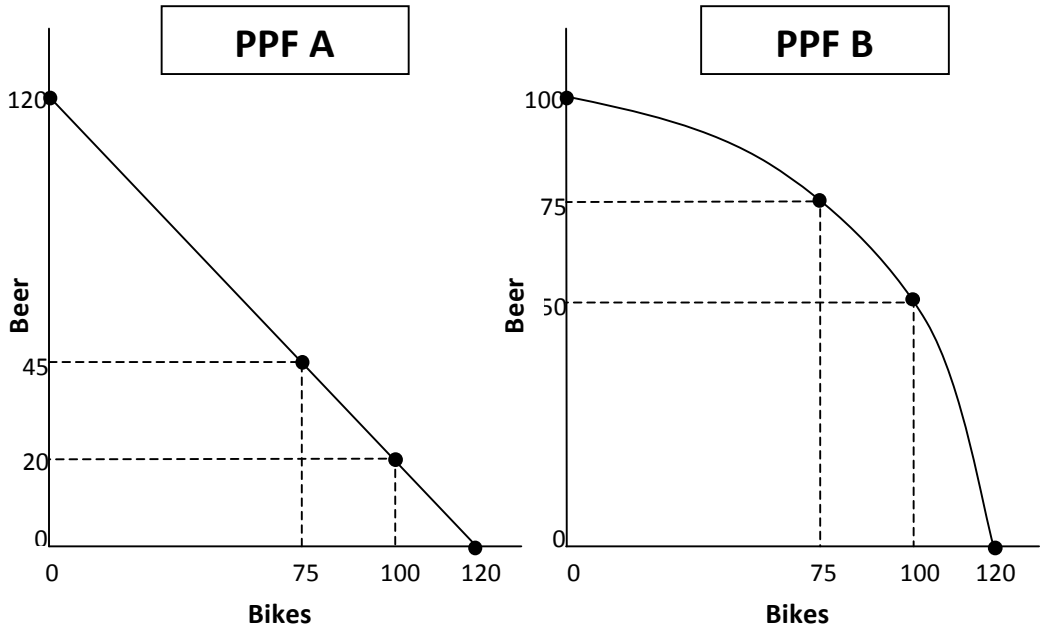
Figure: Tax I



8. **Refer to *Figure: Tax I.*** Panel (a) and Panel (b) each illustrate a $2 tax placed on a market. In comparison to Panel (b), Panel (a) illustrates which of the following statements?

a. When demand is relatively inelastic, the deadweight loss of a tax is smaller than when demand is relatively elastic.
b. When demand is relatively elastic, the deadweight loss of a tax is larger than when demand is relatively inelastic.
c. When supply is relatively inelastic, the deadweight loss of a tax is smaller than when supply is relatively elastic.
d. When supply is relatively elastic, the deadweight loss of a tax is larger than when supply is relatively inelastic.

Figure: PPF



9. **Refer to *Figure: PPF***. What is the opportunity cost of 25 additional beers on PPF B when the country is currently making 100 bikes?

a. 20 bikes
b. 25 bikes
c. 50 bikes
d. 75 bikes

10. **Refer to *Figure: PPF***. Which of the following statements is correct if 100 bikes are efficiently produced on both PPFs?

a. PPF B reflects a comparative advantage in making beer.
b. PPF B reflects a comparative advantage in making bikes.
c. The opportunity cost of making a bike is the same on both PPFs.
d. PPF B reflects an absolute advantage in making bikes.

11. Before the flu season begins, Jeremy gets a flu shot. As a result, Jeremy and several of his friends and relatives avoid the flu for the entire flu season. It would make sense to argue that
a. flu shots provide a positive externality, and that flu shots should be subsidized.
b. if flu shots are not subsidized, then the number of people getting flu shots will be smaller than the socially optimal number.
c. the externality generated by flu shots is more like the externality generated by education than the externality generated by pollution.
d. All of the above are correct.

12. Equilibrium quantity must decrease when demand
a. increases and supply does not change, when demand does not change and supply decreases, and when both demand and supply decrease.
b. increases and supply does not change, when demand does not change and supply increases, and when both demand and supply decrease.
c. decreases and supply does not change, when demand does not change and supply increases, and when both demand and supply decrease.
d. decreases and supply does not change, when demand does not change and supply decreases, and when both demand and supply decrease.

Scenario: International Trade: Let $P_d = 100-3Q_d$ be domestic demand for backpacks and let $P_s=20+2Q_s$ be domestic supply in a small country. The world price of backpacks is $70.

13. **Refer to *Scenario: International Trade.*** What is the domestic equilibrium price if there is no free trade?
a. $16
b. $36
c. $52
d. $64

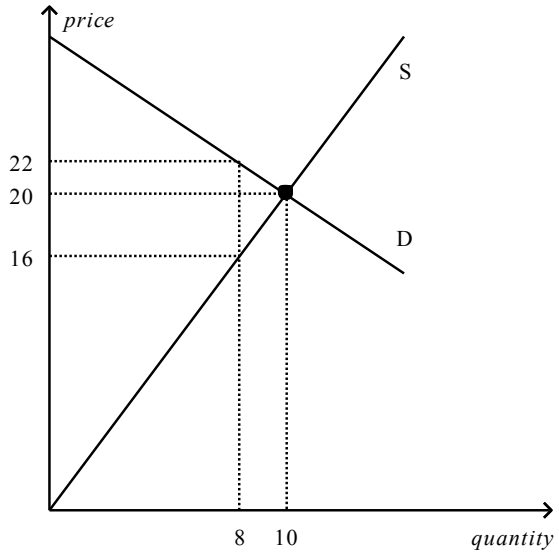
14. **Refer to *Scenario: International Trade.*** Assume this country allows trade. At the world price there will be
a. imports of 15 units.
b. exports of 25 units.
c. exports of 15 units.
d. exports of 10 units.

15. **Refer to *Scenario: International Trade.*** The increase in total surplus as a result of trade is
a. $200
b. $135
c. $270
d. $80

16. **Refer to *Scenario: International Trade.*** Because of the great recession the world price falls to $40. As a result
a. exports fall by 5 units and total surplus declines.
b. the country imports 10 units and consumer surplus rises.
c. the country imports 25 units and consumer surplus rises.
d. domestic production falls 5 units and producer surplus falls.

17. **Refer to *Scenario: International Trade.*** Given a world price of $40, the government decides to protect domestic producers by imposing a tariff of $6. As a result
a. imports decline by 5 units and producer surplus rises.
b. exports rise by 5 units and producer surplus rises.
c. imports decline by 10 units and consumer surplus falls.
d. domestic production rises by 13 units.

Figure: Tax II



18. **Refer to *Figure: Tax II.*** Suppose a tax of $3 per unit is imposed on this market. What will be the new equilibrium quantity in this market?
a. Less than 8 units.
b. 8 units.
c. Between 8 units and 10 units.
d. Greater than 10 units.

19. **Refer to *Figure: Tax II.*** Suppose a tax of $3 per unit is imposed on this market. How much will sellers receive per unit after the tax is imposed?
a. $16
b. Between $16 and $20.
c. Between $20 and $22.
d. $22

20. Your neighbor owns an apple tree, and some of the apples drop into your yard. You don't like to eat apples, and the fallen apples make your yard more difficult to mow and ruin your grass. Your neighbor values the apple tree at $1,000, and your costs associated with the tree are $2,500. Suppose your neighbor has the legal right to keep the tree under any circumstances. If there are no transactions costs to negotiating with your neighbor, what is the likely outcome in

this situation according to the Coase theorem?
a. You call the Department of Public Works to have the tree cut down.
b. You pay your neighbor $2,000 to cut the tree down.
c. Your neighbor pays you $1,500 to not have the tree cut down.
d. Your neighbor pays you $500 to not have the tree cut down.

21. If a shortage exists in a market, then we know that the actual price is
a. above the equilibrium price, and quantity supplied is greater than quantity demanded.
b. above the equilibrium price, and quantity demanded is greater than quantity supplied.
c. below the equilibrium price, and quantity demanded is greater than quantity supplied.
d. below the equilibrium price, and quantity supplied is greater than quantity demanded.

22. A cable television broadcast of a movie is
a. excludable and rival in consumption.
b. excludable and not rival in consumption.
c. not excludable and rival in consumption.
d. not excludable and not rival in consumption.

Table: Clean-up Costs
The following table shows the marginal (not total) costs for each of four firms (A, B, C, and D) to eliminate units of pollution from their production processes. For example, for Firm A to eliminate one unit of pollution, it would cost $60, and for Firm A to eliminate a second unit of pollution would cost an additional $70 (that is, reduction of two units costs a total of $130).

	Firm			
Unit to be eliminated	A	B	C	D
First unit	60	57	54	62
Second unit	70	75	72	73
Third unit	82	86	82	91
Fourth unit	107	108	107	111

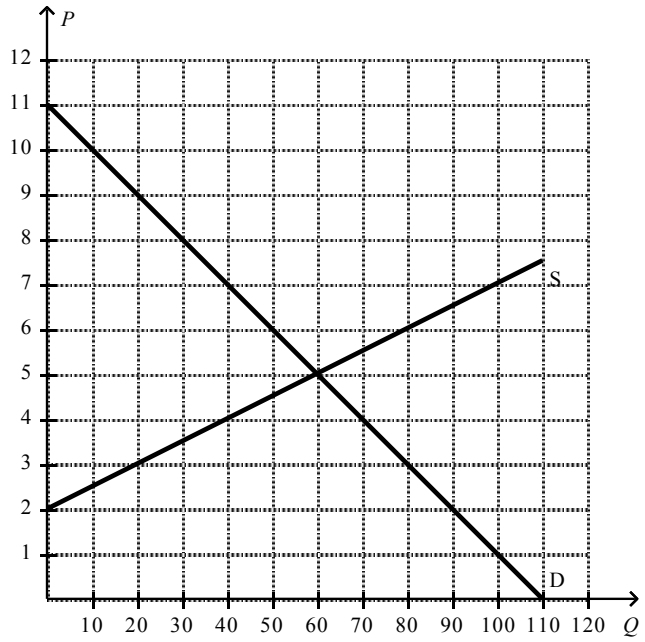
23. **Refer to *Table: Clean-up Costs*.** If the government charged a fee of $74 per unit of pollution, how many units of pollution would the firms eliminate altogether?
a. 7 units
b. 8 units
c. 9 units
d. 10 units

24. When the price of good X is $15, the quantity demanded of good Y is 2,000 units per week. When the price of good X is $10, the quantity demanded of good Y is 3,000 units per week. What are these goods?
a. Normal goods
b. Inferior goods
c. Substitutes
d. Complements

25. When the price of an eBook is $15.00, the quantity demanded is 400 eBooks per day. When the price falls to $10.00, the quantity demanded increases to 700. Given this information and using the midpoint method, we know that the demand for eBooks is

a. inelastic.
b. elastic.
c. unit elastic
d. perfectly inelastic

Figure: Tax III



26. **Refer to *Figure: Tax III*.** Suppose the government changed the per-unit tax on this good from $3.00 to $1.50. Compared to the original tax rate, this lower tax rate would

a. increase tax revenue and increase the deadweight loss from the tax.
b. increase tax revenue and decrease the deadweight loss from the tax.
c. decrease tax revenue and increase the deadweight loss from the tax.
d. decrease tax revenue and decrease the deadweight loss from the tax.

27. Suppose that a worker in Caninia can produce either 2 blankets or 8 meals per day, and a worker in Felinia can produce either 5 blankets or 1 meal per day. Each nation has 10 workers. For many years, the two countries traded, each completely specializing according to their respective comparative advantages. Now war has broken out between them and all trade has stopped. Without trade, Caninia produces and consumes 10 blankets and 40 meals per day and Felinia produces and consumes 25 blankets and 5 meals per day. The war has caused the combined daily output of the two countries to decline by

a. 15 blankets and 35 meals.
b. 25 blankets and 40 meals.
c. 35 blankets and 45 meals.
d. 50 blankets and 80 meals.

28. Suppose that demand is inelastic within a certain price range. For that price range,
a. an increase in price would increase total revenue because the decrease in quantity demanded is proportionately less than the increase in price.
b. an increase in price would decrease total revenue because the decrease in quantity demanded is proportionately greater than the increase in price.
c. a decrease in price would increase total revenue because the increase in quantity demanded is proportionately smaller than the decrease in price.
d. a decrease in price would not affect total revenue.

Table: Willingness to Pay
For each of three potential buyers of apples, the table displays the willingness to pay for the first three apples of the day. Assume Xavier, Yadier, and Zavi are the only three buyers of apples, and only three apples can be supplied per day.

	First Apple	**Second Apple**	**Third Apple**
Xavier	$1.75	$1.55	$1.15
Yadier	$1.50	$1.25	$0.75
Zavi	$1.30	$1.10	$0.70

29. **Refer to *Table: Willingness to Pay*.** If the market price of an apple is $1.40, then the market quantity of apples demanded per day is
a. 1 unit
b. 2 units
c. 3 units
d. 4 units

30. **Refer to *Table: Willingness to Pay*.** If the market price of an apple is $1.40, then consumer surplus amounts to
a. $0.60
b. $1.20
c. $1.40
d. $3.40

Exam 1 Fall 2013-14
Answer Key

Multiple Choice

QUESTION	ANSWER	DIFFICULTY	REFERENCE CHAPTER
1.	A	1/3	6
2.	B	2/3	7
3.	A	2/3	8
4.	C	2/3	8
5.	B	2/3	2
6.	D	1/3	3
7.	B	2/3	11
8.	C	2/3	8
9.	B	2/3	2
10.	A	3/3	3
11.	D	1/3	10
12.	D	2/3	4
13.	C	2/3	4
14.	C	3/3	9
15.	B	3/3	9
16.	B	3/3	9
17.	A	3/3	9
18.	C	1/3	6
19.	B	2/3	6
20.	B	2/3	10
21.	C	1/3	4
22.	B	1/3	11
23.	A	2/3	10
24.	D	2/3	5
25.	B	2/3	5
26.	D	2/3	8
27.	A	2/3	3
28.	A	2/3	5
29.	C	1/3	7
30.	A	2/3	7

Name:_____ Class:_____ Date: _____ ID: A

Final Exam, Fall 2013-14

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

Table: Income Tax Rates for a Single Individual

2009 Tax Rates	Income Ranges	2010 Tax Rates	Income Ranges
15%	$0 – $28,000	10%	$0 – $10,000
25%	$28,000 – $60,000	15%	$10,000 – $30,000
31%	$60,000 – $140,000	27%	$30,000 – $80,000
36%	$140,000 – $300,000	33%	$80,000 – $150,000
40%	over $300,000	38%	$150,000 – $320,000
		41%	over $320,000

1. ***Refer to Table: Income Tax Rates for a Single Individual***. Mia is a single person whose taxable income is $100,000 a year. What happened to her average tax rate from 2009 to 2010?
a. It increased.
b. It decreased.
c. It stayed the same.
d. We don't have enough information to answer this question.

2. ***Refer to Table: Income Tax Rates for a Single Individual***. Mia is a single person whose taxable income is $100,000 a year. What happened to her marginal tax rate from 2009 to 2010?
a. It increased.
b. It decreased.
c. It stayed the same.
d. We don't have enough information to answer this question.

Scenario: Costs. Ellie has been working for an engineering firm and earning an annual salary of $80,000. She decides to open her own engineering business. Her annual expenses will include $15,000 for office rent, $3,000 for equipment rental, $1,000 for supplies, $1,200 for utilities, and a $35,000 salary for a secretary/bookkeeper. Ellie will cover her start-up expenses by cashing in a $20,000 certificate of deposit on which she was earning annual interest of $500, by the time this money is spent she will have enough revenue from her new business to cover expenses.

3. ***Refer to Scenario: Costs.*** Ellie's accounting costs for the first year will be
a. $55,200
b. $75,700
c. $135,700
d. $155,700

4. ***Refer to Scenario: Costs.*** Ellie's economic costs for the first year will be
a. $55,200
b. $75,700
c. $135,700
d. $155,700

Scenario: Perfect Competition I. Suppose a firm's fixed costs are $50 and its marginal cost of producing q units is MC = 10 + 2q. The industry demand curve is given by $P = 40 - Q_D$ (where quantity is given in thousands of units).

5. ***Refer to Scenario: Perfect Competition I.*** If the firm operates in a perfectly competitive industry and the price of the good is $30, what is this firm's optimal short-run quantity?
a. 10 units
b. 0 units
c. 6 units
d. 15 units

6. ***Refer to Scenario: Perfect Competition I.*** If the firm operates in a perfectly competitive industry and the price of the good is $30, how many firms produce this good in the short run?
a. 500
b. 800
c. 1,000
d. 1,200

7. Suppose a monopolistically competitive firm operates in the short run at a price above its average total cost of production. In the long run, the firm should expect
a. new firms to enter the market.
b. the market price to fall.
c. its prices to fall.
d. All of the above are correct.

Scenario: Forest. Four brothers share a forest with 2,000 acres of trees. To preserve the forest, the government promises to pay the group $400,000 minus $200 per acre of trees that has been cut down (this money will be split evenly among the brothers). Each brother can cut down and sell trees for $100 per acre.

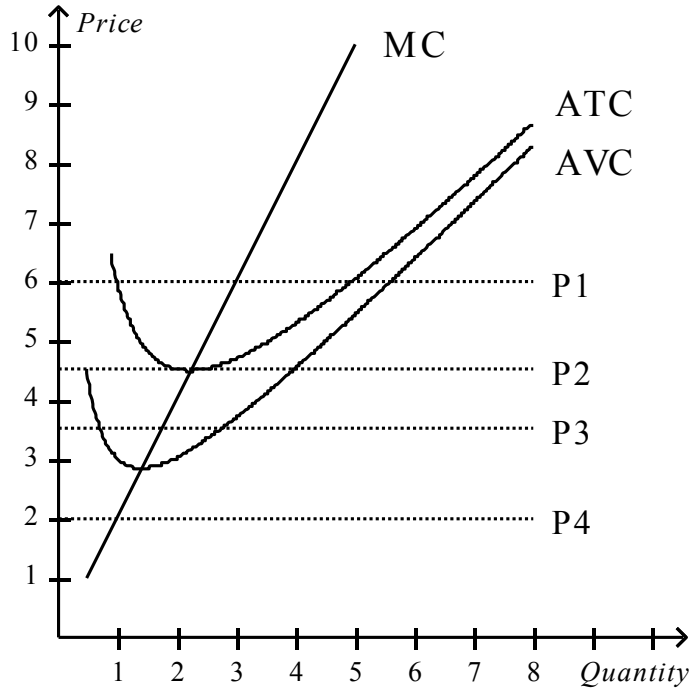
8. ***Refer to Scenario: Forest.*** What total quantity of cut tree acres maximizes the profit of the group? **Difficulty 2/3**
a. 0 acres
b. 100 acres
c. 1,000 acres
d. 2,000 acres

9. ***Refer to Scenario: Forest.*** What is the symmetric Nash equilibrium quantity of cut tree acres per individual? **Difficulty 2/3**
a. 0 acres
b. 100 acres
c. 1,000 acres
d. 500 acres

10. ***Refer to Scenario: Forest.*** Which phrase best describes the forest in this scenario? **Difficulty 1/3**
a. Public good
b. Common resource
c. Private good
d. Natural monopoly / Club good

11. Suppose a firm must pay $100 per day per worker. If the firm hires 1 worker, it can produce 25 units of output. If the firm hires 2 workers, it can produce 60 units of output. If the firm hires 3 workers, it can produce 95 units of output. And if the firm hires 4 workers, it can produce 120 units of output. For which worker does the firm experience diminishing marginal product of labor?
a. First worker
b. Second worker
c. Third worker
d. Fourth worker

Figure: Perfect Competition I.



12. ***Refer to Figure: Perfect Competition I.*** Suppose a firm in a competitive industry has the following cost curves. If the price if P1 in the short run, what will happen in the long run?
a. Nothing. The price is consistent with zero economic profits, so there is no incentive for firms to enter or exit the industry.
b. Individual firms will earn positive economic profits in the short run, which will entice other firms to enter the industry.
c. Individual firms will earn negative economic profits in the short run, which will cause some firms to exit the industry.
d. Because the price is below the firm's average variable costs, the firms will shut down.

Scenario: Perfect Competition II. Suppose a competitive firm is producing Q=500 units of output. The marginal cost of the 500th unit is $17, and the average total cost of producing 500 units is $12. The firm sells its output for $20.

13. ***Refer to Scenario: Perfect Competition II.*** At Q=500, the firm's profits equal
a. $1,000.
b. $4,000.
c. $7,000.
d. $10,000.

14. ***Refer to Scenario: Perfect Competition II.*** At Q=500, the firm should
a. increase output to increase economic profit.
b. decrease output to increase economic profit
c. profit is maximized at Q=500.
d. None of these answers is necessarily correct.

Table: Game I.

		Firm 2			
		W	**X**	**Y**	**Z**
Firm 1	**A**	(2,9)	(6,8)	(7,7)	(6,6)
	B	(5,4)	(8,5)	(6,4)	(5,3)
	C	(4,9)	(4,3)	(5,6)	(2,8)
	D	(3,3)	(7,4)	(4,3)	(7,3)

15. ***Refer to Game I.*** Which outcome is a Nash equilibrium of this game? **Difficulty 2/3**
a. (B,X)
b. (A,Y)
c. (C,W)
d. (D,Z)

16. ***Refer to Game I.*** A total of how many actions can be eliminated by the iterated deletion of dominated strategies?
a. 0
b. 1
c. 3
d. 6

Table: Monopoly

Price	Quantity
$8	300
$7	400
$6	500
$5	600
$4	700
$3	800
$2	900
$1	1,000

17. ***Refer to Table: Monopoly.*** The monopolist has fixed costs of $1,000 and has a constant marginal cost of $2 per unit. If the monopolist were able to perfectly price discriminate, how many units would it sell?
a. 500 units
b. 700 units
c. 900 units
d. 1,000 units

18. Consider two cigarette companies, PM Inc. and Brown Inc. If neither company advertises, the two companies split the market and earn $50 million each. If they both advertise, they again split the market, but profits are lower by $10 million since each company must bear the cost of advertising. If one company advertises while the other does not, the one that advertises attracts customers from the other. In this case, the company that advertises earns $60 million while the company that does not advertise earns only $30 million. What will the two companies do if they behave as individual profit maximizers?
a. Neither company will advertise.
b. Both companies will advertise.
c. One company will advertise, the other will not.
d. The question requires we know how many customers are stolen through advertising.

19. Regulating natural monopolies by making them set price equal to marginal cost would
a. cause the monopolist to operate at a loss.
b. result in less than optimal total surplus.
c. maximize producer surplus.
d. result in higher profits for the monopoly.

Table: Average Total Cost. Each entry in the table represents the average total cost (per unit) of producing the specified number of units.

Output	Small Factory	Medium Factory	Large Factory	Extra Large Factory
100 units	$125	$200	$325	$500
200 units	$85	$125	$190	$350
300 units	$80	$90	$100	$200
400 units	$120	$75	$80	$120
500 units	$200	$95	$70	$90
600 units	$390	$185	$110	$85
700 units	$625	$300	$180	$130
800 units	$900	$475	$325	$195

20. ***Refer to Table: Average Total Cost***. Which entry is NOT on the firm's long-run average total cost (LRATC) curve?
a. 200 units, LRATC = $85
b. 400 units, LRATC = $75
c. 600 units, LRATC = $110
d. 800 units, LRATC = $195

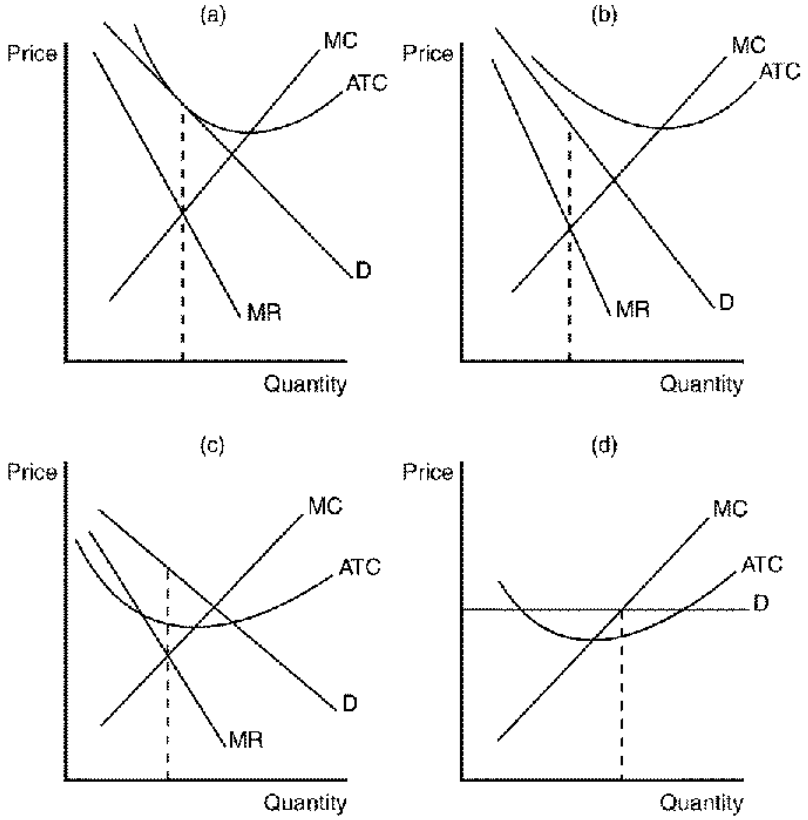
21. ***Refer to Table: Average Total Cost***. At which level of output does the firm first experience diseconomies of scale in the long run?
a. 300 units
b. 500 units
c. 600 units
d. 800 units

Table: Income Tax Rates for Single vs. Married

Rate	Single Income Ranges	Married Income Ranges
10%	$0 – $9,000	$0 – $18,000
15%	$9,000 – $36,000	$18,000 – $73,000
25%	$36,000 – $88,000	$73,000 – $146,000
28%	$88,000 – $183,000	$146,000 – $223,000
33%	$183,000 – $398,000	$223,000 – $398,000
35%	$398,000 - $400,000	$398,000 - $450,000
40%	over $400,000	over $450,000

22. ***Refer to Table: Income Tax Rates for Single vs. Married***. Mia and Matt have been dating for several years and they are thinking about getting married. They each make $150,000 per year. If they do get married, what is their "marriage penalty"? That is, how much more will they pay in taxes as a married couple than they would if they were both single?
a. There is no marriage penalty
b. $2,560
c. $4,650
d. $6,120

Figure: Monopolistic Competition



23. ***Refer to Figure: Monopolistic Competition.*** Which of the graphs depicts a short-run equilibrium that will encourage the entry of other firms into a monopolistically competitive industry?

a. Panel (a)
b. Panel (b)
c. Panel (c)
d. Panel (d)

Table: Game II.

		Firm 2		
		X	**Y**	**Z**
Firm 1	**A**	(4,4)	(2,2)	(7,3)
	B	(7,7)	(3,8)	(9,6)
	C	(3,5)	(4,6)	(8,4)

24. ***Refer to Table: Game II.*** How many pure strategy Nash equilibria exist in this game? **Difficulty 2/3**

a. 0
b. 2
c. 3
d. 1

Table: Oligopoly. The information in the table below shows the total demand for premium-channel digital cable TV subscriptions in a small urban market. Assume that each cable operator pays a fixed cost of $200,000 (per year) to provide premium digital channels in the market area and that the marginal cost of providing the premium channel service to a household is zero.

Quantity	Price (per year)
0	$180
3,000	$150
6,000	$120
9,000	$ 90
12,000	$ 60
15,000	$ 30
18,000	$ 0

25. ***Refer to Table: Oligopoly.*** Assume there are two digital cable TV companies operating in this market. If they are able to collude on the quantity of subscriptions that will be sold and on the price that will be charged for subscriptions, then their agreement will stipulate that
a. each firm will charge a price of $60 and each firm will sell 6,000 subscriptions.
b. each firm will charge a price of $90 and each firm will sell 4,500 subscriptions.
c. each firm will charge a price of $120 and each firm will sell 3,000 subscriptions.
d. each firm will charge a price of $150 and each firm will sell 1,500 subscriptions.

26. ***Refer to Table: Oligopoly.*** Assume there are two profit-maximizing digital cable TV companies operating in this market. Further assume that they are not able to collude on the price and quantity of premium digital channel subscriptions to sell. What price will premium digital channel cable TV subscriptions be sold at when this market reaches a Nash equilibrium under Cournot (quantity) competition?
a. $30
b. $60
c. $90
d. $120

Table: Tax Systems

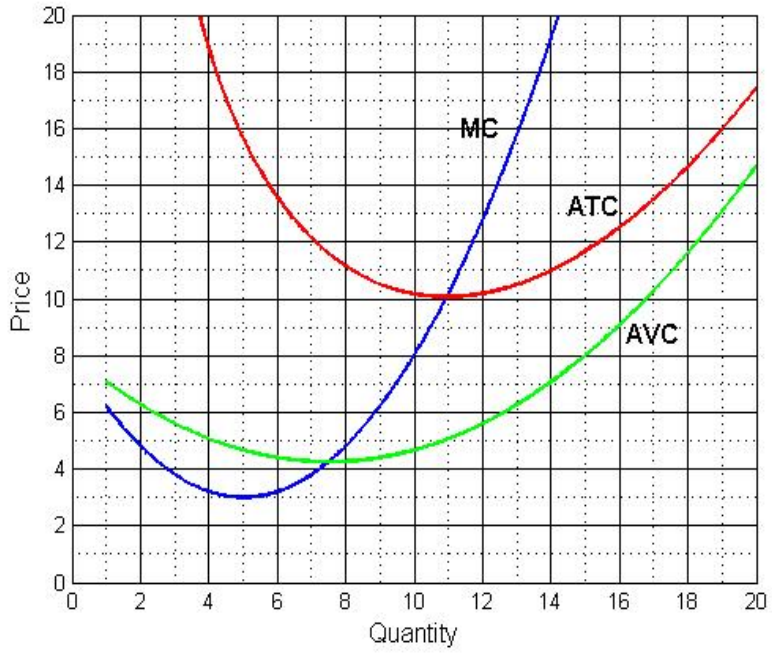
	Tax A	***Tax B***	***Tax C***
Income	***Tax Rate***	***Tax Rate***	***Tax Rate***
$0 - $50,000	***30%***	***25%***	***20%***
$50,000 - $100,000	***25%***	***25%***	***25%***
over $100,000	***20%***	***25%***	***30%***

27. ***Refer to Table: Tax Systems***. Which represents a proportional tax?
a. Tax A
b. Tax B
c. Tax C
d. None of the above

28. ***Refer to Table: Tax Systems***. Which represents a lump-sum tax?
a. Tax A
b. Tax B
c. Tax C
d. None of the above

29. Which of the following is NOT a barrier to entry that leads to the rise of monopoly power?
a. Annual rental contracts that cannot be broken.
b. Government grants an exclusive right to produce a good.
c. Declining ATC curve for all quantities.
d. Ownership of a key resource.

Figure: Perfect Competition II

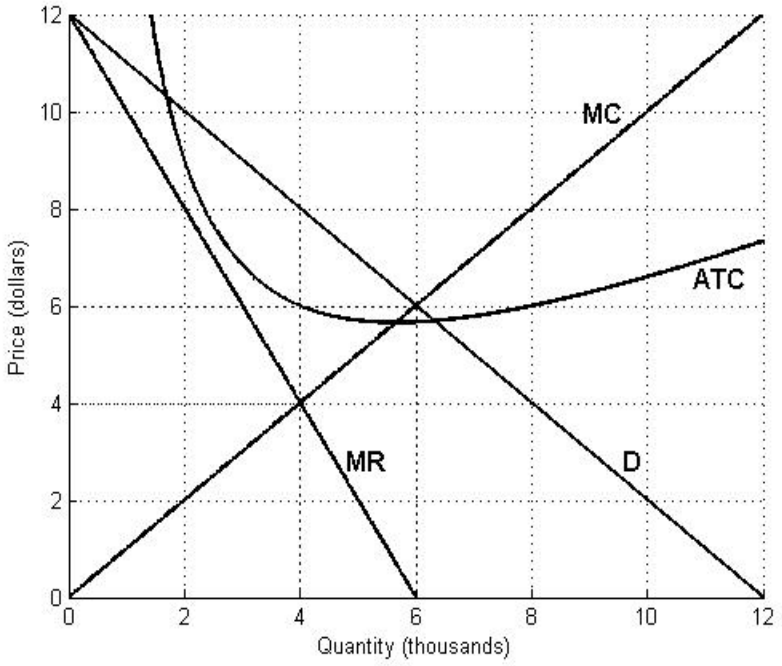


30. ***Refer to Figure: Perfect Competition II.*** What is this firm's shut-down price? **Difficulty 1/3**
a. $2.50
b. $10
c. $4.25
d. $8

31. ***Refer to Figure: Perfect Competition II.*** If this perfectly competitive firm faces a price of $19 per unit of its product, what is its total profit? **Difficulty 2/3**
a. $64
b. $112
c. $85
d. $168

32. ***Refer to Figure: Perfect Competition II.*** If the current market price is $8 and all other firms in the industry are identical to this one, what can we expect to happen in the long-run? **Difficulty 1/3**
a. Some firms will exit the industry, causing the equilibrium price to rise.
b. Some firms will exit the industry, causing the equilibrium price to fall.
c. Demand for the product will fall, causing the equilibrium price to fall.
d. Demand for the product will rise, causing the equilibrium price to rise.

Figure: Monopoly.



33. ***Refer to Figure: Monopoly.*** What is this monopolist's profit if it cannot price discriminate? **Difficulty 2/3**

a. $1,500
b. $8,000
c. $16,000
d. $36,000

Scenario: Cost. Suppose a firm's total costs are given by $TC = 200 + 0.5(Q + Q^2)$, in dollars.

34. ***Refer to Scenario: Cost.*** What is the firm's marginal cost of the third unit of output (the correct answer below assumes you will use the discrete definition of marginal cost, if you use calculus choose the nearest answer).

a. $3
b. $6
c. $12
d. $206

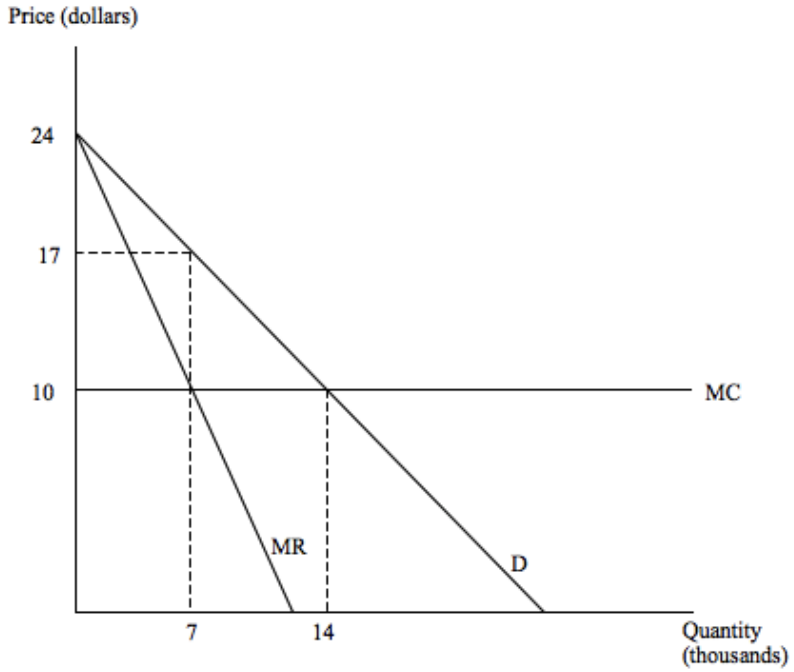
35. ***Refer Scenario: Cost.*** What is the fixed cost facing the firm?

a. $0.50
b. $50
c. $100
d. $200

36. What is a key difference between firms in a perfectly competitive versus a monopolistically competitive industry? **Difficulty 1/3**

a. Marginal cost pricing versus mark-up.
b. Efficient scale versus excess capacity.
c. Identical products versus slightly differentiated products.
d. All of the above.

Figure: Constant Marginal Cost



37. ***Refer Figure: Constant Marginal Cost.*** Suppose there are no fixed costs. What is the deadweight loss due to monopoly?

a. $20
b. $40
c. $24.50
d. $49

Scenario: Firm Costs. Suppose a firm has total cost curve TC = 64 + 6Q +Q^2 and marginal cost curve MC = 6 +2Q.

38. ***Refer to Scenario: Firm Costs.*** If the firm is perfectly competitive, what is its exit price?

a. $18
b. $20
c. $22
d. $24

39. ***Refer to Scenario: Firm Costs.*** Suppose the costs above belong to a monopolist facing demand curve P = 36 – 2Q. What is the firm's profit-maximizing price?

a. $26
b. $31
c. $24
d. $29

40. ***Refer to Scenario: Firm Costs.*** Suppose the costs above belong to a monopolist facing demand curve P = 36 – 2Q. What is the firm's profit?

a. $13
b. $11
c. $9
d. $7

Final Exam, Fall 2013-14
Answer Section

Multiple Choice

1.	ANS: B	DIF: 2/3	Ref: Ch. 12
2.	ANS: A	DIF: 1/3	Ref: Ch. 12
3.	ANS: A	DIF: 2/3	Ref: Ch. 13
4.	ANS: C	DIF: 2/3	Ref: Ch. 13
5.	ANS: A	DIF: 1/3	Ref: Ch. 14
6.	ANS: C	DIF: 2/3	Ref: Ch. 14
7.	ANS: D	DIF: 1/3	Ref: Ch. 16
8.	ANS: A	DIF: 2/3	Ref: Ch. 17
9.	ANS: D	DIF: 2/3	Ref: Ch. 17
10.	ANS: B	DIF: 1/3	Ref: Ch. 9
11.	ANS: D	DIF: 2/3	Ref: Ch. 13
12.	ANS: B	DIF: 1/3	Ref: Ch. 14
13.	ANS: B	DIF: 2/3	Ref: Ch. 14
14.	ANS: A	DIF: 2/3	Ref: Ch. 14
15.	ANS: A	DIF: 2/3	Ref: Ch. 17
16.	ANS: D	DIF: 2/3	Ref: Ch. 17
17.	ANS: C	DIF: 1/3	Ref: Ch. 15
18.	ANS: B	DIF: 2/3	Ref: Ch. 17
19.	ANS: A	DIF: 2/3	Ref: Ch. 15
20.	ANS: C	DIF: 2/3	Ref: Ch. 13
21.	ANS: C	DIF: 2/3	Ref: Ch. 13
22.	ANS: C	DIF: 3/3	Ref: Ch. 12
23.	ANS: C	DIF: 1/3	Ref: Ch. 16
24.	ANS: D	DIF: 2/3	Ref: Ch. 17
25.	ANS: B	DIF: 3/3	Ref: Ch. 17
26.	ANS: B	DIF: 2/3	Ref: Ch. 17
27.	ANS: B	DIF: 1/3	Ref: Ch. 12
28.	ANS: D	DIF: 1/3	Ref: Ch. 12
29.	ANS: A	DIF: 1/3	Ref: Ch. 15
30.	ANS: C	DIF: 1/3	Ref: Ch. 14
31.	ANS: B	DIF: 2/3	Ref: Ch. 14
32.	ANS: A	DIF: 1/3	Ref: Ch. 14
33.	ANS: B	DIF: 2/3	Ref: Ch. 15
34.	ANS: A	DIF: 2/3	Ref: Ch. 13
35.	ANS: D	DIF: 1/3	Ref: Ch. 13
36.	ANS: D	DIF: 1/3	Ref: Ch. 16
37.	ANS: C	DIF: 2/3	Ref: Ch. 15
38.	ANS: C	DIF: 3/3	Ref: Ch. 14
39.	ANS: A	DIF: 3/3	Ref: Ch. 15
40.	ANS: B	DIF: 2/3	Ref: Ch. 15