Microeconomics I
Group Assignment 2

It takes over one year and many production workers to build a *Steinway Model D* grand piano, which has more than 12,000 parts. Such a grand piano is obviously extremely expensive, and over the past few decades the factory has on average produced only around 110 of them per year. The production process involves many different activities, and although most of them cannot be fully automated, machinery can be used to help the workers. E.g. a "pounder" machine can be used to break the pianos in by pounding every key 8,000 times within 45 minutes (under the watchful eye of a process operator), but this pounding could also be done by hand (and would then obviously require much more labor time). Similarly, the final tuning of the pianos can be done using only a tuning-fork and the human ear, or (in a much less labor-intensive fashion) using ultra-sensitive microphones and specialized software.

Figure 1: The favourite instrument of many concert pianists: Steinway's model D. A brand new one will cost you over $150,000.

The following table describes Steinway's production function, indicating how pro-

duction depends on the number of workers employed and the units of capital (say: machinery) used.

Output Quantities Steinway Model D

Capital *K* \ Labour *L*	0	10	20	30	40	50	60
0	0	0	0	0	0	0	0
5	0	18	40	77	110	141	170
10 ⇒ *current value!*	0	40	110	170	200	225	245
15	0	77	170	210	245	275	300
20	0	110	200	245	280	315	345
25	0	141	225	275	315	350	385
30	0	170	245	300	345	385	420

A. The Short-run.

In the short run, Steinway uses 10 units of capital in its production process and has no way of increasing this amount quickly. The only thing that Steinway can do to match a boost in the demand for its pianos is to hire extra labor. Similarly, it can't sell or rent its specialized capital to other piano manufacturers, so it has to lay off people when the market for Model D collapses.

Using the table it is not hard to determine Steinway's short-run total product of labor curve, as well as two derived curves, the marginal and the average product of labor curves. Steinway can use these curves to examine whether the law of diminishing marginal returns also applies to the production of its Model D. Steinway shows great interest in the amount of labor that maximizes the average product of labor and wonders whether this amount is in any way related to the marginal product of its workers.

(a) (5 points) What is the distinction between the short-run and the long-run. Explain in as much detail as you can.

(b) (15 points) How to derive Steinway's total, average, and marginal product of labor curve from the available numerical information? Use *Excel* to determine

the average and marginal products of labor, over the available range of the labor input (be sure to submit your excel file together with your assignment).

(c) (15 points) On the basis of your result at (b), plot the total productivity of labor, average productivity of labor, and marginal productivity of labor curves, using *Excel* (be sure to submit your excel file together with your assignment). **Caveat:** Unfortunately, the table at the start of the task only provides the output levels at a very limited number of capital-labor combinations: e.g. given $K = 10$, we only know the output for $L = 0, 10, 20, ..., 60$, but not for intermediate levels of the labor input. Consequently, the average and marginal product of labor curves can only be drawn with limited precision. One annoying implication of this: *the theoretical property that the marginal product curve hits the average product curve at its maximum may only hold approximately, not exactly.* This does not indicate that there is anything wrong with your graph, let alone with the underlying theory!

(d) (10 points) What is the law of diminishing marginal returns about and does it apply to Steinway?

(e) (5 points) What is the relation between maximal average productivity and marginal productivity?

B. The Long-run.

In the long run, Steinway is free to alter the amounts of labor and capital that it uses. To get a handle on its long-run production function, it is useful to describe the production process by isoquants – curves that show the efficient combinations of labor and capital that can produce a specific level of output, e.g. 110 or 170 units. From the isoquants it is easily seen whether a production process exhibits constant, decreasing or increasing returns to scale.

The progress in Steinway's technology has been rather limited over the years. By means of extreme example, the firm still uses some equipment that was built in the Victorian era, such as a veneer-edge cutter from 1871. But modern equipment is used to refine the tools they use, to improve the tolerances of action parts, and to make parts that don't need custom fitting. E.g. a computer-aided router cuts the final shape of the top lid, and engineers use CAD/CAM software on a computer to redesign action parts. Such tasks required much more labor in the old days. As a consequence, Steinway has experienced a limited amount of non-neutral technical change, causing its isoquants to change over time.

(a) (20 points) What do Steinway's isoquants look like, given the available numerical information? Use the information in the table at the start of the assignment to sketch the isoquants for $Q = 110$ and $Q = 170$ using *Excel*.

(b) (5 points) Explain what constant, decreasing, and increasing returns to scale are in detail. Give examples of industries that exhibit such returns to scales for each of them.

(c) (10 points) What kind of returns to scale does Steinway face? Show your work explicitly.

(d) (5 points) What is marginal rate of technical substitution? Explain it in as much detail as you can.

(e) (5 points) What is non-neutral technical progress?

(f) (5 points) What is the effect of non-neutral technical progress on the isoquants of Steinway?