



In Class Exercises (ICE) - 2/16/01

When people undergo major surgery (such as a hip replacement) they are normally given doses of morphine to help them cope with the pain of surgery. In the past, nurses administered injections of morphine every few hours. Nowadays, patients are usually connected to a “pain pump” (see Figure 1) that continuously administers small doses of morphine to the patient.



Figure 1: Pain pump manufactured by Stryker Industries.

Generally speaking, patients find this a more satisfactory arrangement, as the pain is kept at a constant, low level, rather than rising to very painful levels just before an injection is given. In this ICE, you'll work out the concentration of morphine in a patient's bloodstream when they are using a pain pump.

- The half-life of the morphine¹ in the human body is about 4 hours². Morphine obeys the linear law of pharmacokinetics (i.e. $dC/dt = kC$). Find the constant of proportionality that will give a half-life of four hours.**

¹ A common product used in hospitals is the drug Roxanol®. The active ingredient in Roxanol® is morphine sulfate. The usual adult dosage of Roxanol (administered intravenously or orally) is 10-30 mg every 4 hours. (Source: Roxane Laboratories. www.roxane.com)

² Source: Forensic Toxicology Drug Information Sheet (2000). Distributed by the Toxicology and Accident Research Laboratory, Federal Aviation Administration Office of Aviation Medicine.

• **Suppose that a pain pump is supplying morphine to a patient at a rate of 4mg per hour. Modify your differential equation to reflect this. (Assume that a person, on average, has about 4700ml of blood³.)**

• **Solve your differential equation to find a formula for morphine concentration in the blood as a function of time. If the patient is given an injection of 50mg of Roxanol[®] immediately after surgery, and then put on the pain pump, how can you incorporate this information in your formula?**

• **Depending on the person, the minimum lethal concentration of morphine in the blood is between 5mg/100ml and 40mg/100ml⁴. Is the patient represented by your formula in any danger of receiving a lethal dose of morphine?**

³ Source: World Book Encyclopedia (1998 Edition). The encyclopedia states that "...an adult who weighs 160 pounds has about 5 quarts (4.7 liters) of blood." (page 407)

⁴ Source: Forensic Toxicology Drug Information Sheet (2000).