You should be able to complete the exam in 50 minutes. However, if you need more time, you are free to stay after class if you'd like. If you anticipate needing more time and cannot stay (due to other classes or conflicts), let me know and perhaps we can work something out (e.g., you can start the exam earlier).

Please email me if you have questions about the exam.

Section A

When working on these, do not spend too much time on each one. A minute or two should be sufficient. You need to leave some time for section B.

Also, try to think about the purpose of the question. For example, if it is to distinguish between different units or variables, make sure you are using the scientific definition. Also, if you can limit the choices to two, choose both. You can go back later if you have some time.

I apologize in advance for any errors in this answer key.

1. d
2. a
3. e
4. b
5. b
6. d
7. d
8. e (note that ”m” stands for ”meter”, not ”mile”)
9. c (the slope at 5 seconds is not the same as the average slope from 0 to 5 seconds)
10. e (can't add values that have different units)

Section B

This section will probably consist of four or five problems. Keep track of your units. Also make sure your answer makes sense. Don't just trust your math!

1. $x = (25\ \text{m/s}^4))t^4 + (3\ \text{m})$
2. ma has units of kg·m·s^{-2} (multiply units of m by units of a) whereas kx has units of kg·s^{-2}·m (multiply units of k by units of x). Rearrange algebraically to show these two are equivalent.
3. There are no units provided. Without the units, one cannot interpret the number.
4. To convert m^2 to cm^2, one can multiply by

$$\left(\frac{1\ \text{m}}{100\ \text{cm}}\right)^2$$

   to get 1.4×10^{-4} kW/cm^2. To convert kW to W, one can multiply by

$$\left(\frac{1000\ \text{W}}{1\ \text{cm}}\right)$$

   to get 1.4×10^{-1} W/cm^2 or 0.14 W/cm^2.
5. To convert, multiply by

$$\left(\frac{12\ \text{in}}{1\ \text{ft}}\right)^2 \left(\frac{2.54\ \text{cm}}{1\ \text{in}}\right)^2$$

   to get 7430 cm^2.
6. This depends on the age of the human and the heart rate. However, we can make reasonable guesses about typical values. Assuming a lifetime of 80 years and an average heart rate of 70 beats per minute, one can convert to get the following:

$$\frac{70\ \text{beat}}{1\ \text{min}}\frac{60\ \text{min}}{1\ \text{h}}\frac{24\ \text{h}}{1\ \text{d}}\frac{365.2425\ \text{d}}{1\ \text{y}}\frac{80\ \text{y}}{1\ \text{lifetime}} = 2.945 \times 10^9\ \text{beats/lifetime}$$

   which we can round to 3 billion beats per lifetime. Since the initial values (heart rate and lifetime) are estimates, we don't really need to know the other values so precisely. To make the math easier, we could approximate those values as well and still get around 3 billion in the end.
7. Multiply the factors together $(2 \times 1.5 \times 1.2)$ to get a factor of 3.6.

8. Since $T^2 \propto r^3$, then if the distance is doubled, that means T^2 must go up by 2^3 or 8 times. If T^2 goes up by 8 times the original value, that means T must go up by $\sqrt{8}$ or 2.8 times (about 3 times). The actual ratio of the periods ends up by 3.05 but the actual ratio of the distances is not exactly two.

9. The total volume of viral particles is $(0.010\ \text{cm}^3)\times(10^{-9}) = 10^{-11}\ \text{cm}^3$. Converting to m^3, this is $10^{-17}\ \text{m}^3$.

   Each virus has a size equal to ${}^4/_3\pi r^3$, where r is equal to 42.5 nm (half of the diameter) or 4.25×10^{-8} m. That gives a volume of 3.216×10^{-22} m^3.

   Divide the total volume by the volume of each virus to get 3.11×10^4 viruses (31,100).