Power Series Solutions for Differential Equations
Introduction to Hooke's Law

(1) Let $y = A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5 + Gx^6 + \ldots$ be an Infinite MacLaurin Power Series approximating the Solution Curve for the following Differential Equation with Initial Condition:

$$y' = x + 1 \qquad y(0)=2.$$

(1a) Use the given MacLaurin Series to solve this Differential Equation.
(1b) Classify your series solution:
finite or infinite.
(1c) Check this solution by substitution.
(1d) Graph this solution and classify the function:
power, exponential, logarithmic, sinusoidal, logistic, other.

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(2) Let $y = A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5 + Gx^6 + \ldots$ be an Infinite MacLaurin Power Series approximating the Solution Curve for the following Differential Equation with Initial Condition:

$$y' = x^2 - x + 5 \qquad y(0)=0.$$

(2a) Use the given MacLaurin Series to solve this Differential Equation.
(2b) Classify your series solution:
finite or infinite.
(2c) Check this solution by substitution.
(2d) Graph this solution and classify the function:
power, exponential, logarithmic, sinusoidal, logistic, other.

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(3) Let $y = A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5 + Gx^6 + \ldots$ be an Infinite MacLaurin Power Series approximating the Solution Curve for the following Differential Equation with Initial Condition:

$$y' = y \qquad y(0)=1.$$

(3a) Use the given MacLaurin Series to solve this Differential Equation.
(3b) Classify your series solution:
finite or infinite.
(3c) Graph this solution and classify the function:
power, exponential, logarithmic, sinusoidal, logistic, other.
(3d) Solve the Differential Equation by the Method of Separation of Variables. Does this solution match your function classification?

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(4) Let $y = A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5 + Gx^6 + \ldots$ be an Infinite MacLaurin Power Series approximating the Solution Curve for the following Differential Equation with Initial Condition:

$$y' = -y \qquad y(0)=2.$$

(4a) Use the given MacLaurin Series to solve this Differential Equation.
(4b) Classify your series solution:
finite or infinite.
(4c) Graph this solution and classify the function:
power, exponential, logarithmic, sinusoidal, logistic, other.
(4d) Solve the Differential Equation by the Method of Separation of Variables. Does this solution match your function classification?

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(5) Let $y = A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5 + Gx^6 + \ldots$ be an Infinite MacLaurin Power Series approximating the Solution Curve for the following Differential Equation with Initial Condition:

$$y' = \frac{1}{1+x} \qquad y(0)=1.$$

(5a) Use the given MacLaurin Series to solve this Differential Equation.
(5b) Classify your series solution:
finite or infinite.
(5c) Graph this solution and classify the function:
power, exponential, logarithmic, sinusoidal, logistic, other.
(5d) Solve the Differential Equation by the Method of Separation of Variables. Does this solution match your function classification?

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(6) Let $y = A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5 + Gx^6 + \ldots$ be an Infinite MacLaurin Power Series approximating the Solution Curve for the following Differential Equation with Initial Condition:

$$y' = \frac{1}{1-x} \qquad y(0)=1.$$

(6a) Use the given MacLaurin Series to solve this Differential Equation.
(6b) Classify your series solution:
finite or infinite.
(6c) Graph this solution and classify the function:
power, exponential, logarithmic, sinusoidal, logistic, other.
(6d) Solve the Differential Equation by the Method of Separation of Variables. Does this solution match your function classification?

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(7) Let $y = A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5 + Gx^6 + \ldots$ be an Infinite MacLaurin Power Series approximating the Solution Curve for the following Differential Equation with Initial Condition:

$$y' = x + y \qquad y(0)=1.$$

(7a) Use the given MacLaurin Series to solve this Differential Equation.
(7b) Classify your series solution:
finite or infinite.
(7c) Graph this solution and classify the function:
power, exponential, logarithmic, sinusoidal, logistic, other.
(7d) Solve this 1st Order Differential Equation using the Method of Separation of Variables if possible. If this is not possible, explain why.

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(8) Let $y = A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5 + Gx^6 + \ldots$ be an Infinite MacLaurin Power Series approximating the Solution Curve for the following Differential Equation with Initial Condition:

$$y' = x - y \qquad y(0) = -1.$$

(8a) Use the given MacLaurin Series to solve this Differential Equation.
(8b) Classify your series solution:
finite or infinite.
(8c) Graph this solution and classify the function:
power, exponential, logarithmic, sinusoidal, logistic, other.
(8d) Solve this 1st Order Differential Equation using the Method of Separation of Variables if possible. If this is not possible, explain why.

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(9) Let $y = A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5 + Gx^6 + \ldots$ be an Infinite MacLaurin Power Series approximating the Solution Curve for the following Differential Equation with Initial Condition:

$$y'' = -y \qquad y(0)=0,\ y'(0)=1.$$

(9a) Use the given MacLaurin Series to solve this Differential Equation.
(9b) Classify your series solution:
finite or infinite.
(9c) Graph this solution and classify the function:
power, exponential, logarithmic, sinusoidal, logistic, other.
(9d) Solve this 1st Order Differential Equation using the Method of Separation of Variables if possible. If this is not possible, explain why.

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(10) Let $y = A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5 + Gx^6 + \ldots$ be an Infinite MacLaurin Power Series approximating the Solution Curve for the following Differential Equation with Initial Condition:

$$y'' = -y \qquad y(0)=1,\ y'(0)=0.$$

(10a) Use the given MacLaurin Series to solve this Differential Equation.

(10b) Classify your series solution:
finite or infinite.

(10c) Graph this solution and classify the function:
power, exponential, logarithmic, sinusoidal, logistic, other.

(10d) Use Newton's 2nd Law of Motion (net $\overline{\mathbf{F}} = m\,\overline{\mathbf{a}}$) and Hooke's Law for Springs ($\overline{\mathbf{F}} = -k\,\overline{\mathbf{s}}$) to show that the displacement of an object suspended by a spring follows a differential model similar to the one you just solved ($\frac{d^2\,\overline{(\mathbf{s(t)})}}{dt^2} = \frac{-k}{m}\,\overline{\mathbf{s(t)}}$) !

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Teacher's notes:

Model power series solutions by doing the odd questions from this packet and grade the rest.