AP Calculus BC

	Key Standards Covered	Possible Resources
Quarter 1 September 6- November 2	● E.K.2.3F2: For differential equations, Euler's Method provides procedures for approximating a solution or a point on solution curve. ● E.K.3.2D1 : An improper integral is an integral that has one or both limits infinite or has an integrand that is unbounded in the interval of integration. ● E.K.3.2D: Improper Integrals can determined using limits of definite integrals. ● EK 3.5B1: The model for exponential growth and decay that arises from the statement "The rate of change of a quantity is proportional to the size of the quantity" is.	● Project: Weight Loss
	Key Standards Covered	**Possible Resources**
Quarter 2 November 12- January 28	● EK 3.3B4: Many functions do not have closed form antiderivatives. ● EK 3.3B5: Techniques for finding antiderivatives include algebraic manipulation such as long division and completing the square, substitution of variables	● Project : Power Lines
	Key Standards Covered	**Possible Resources**

Quarter 3 February 4- April 5	• LO 3.4C: Apply definite integrals to problems involving motion. • LO 3.4D: Apply definite integrals to problems involving area, volume, (BC) and length of a curve. • EK 3.4C1: (BC) The definite integral can be used to determine displacement, distance, and position of a particle moving along a curve given by parametric or vector-valued functions. • EK 3.4D1: Areas of certain regions in the plane can be calculated with definite integrals. (BC) Areas bounded by polar curves can be calculated with definite integrals.	• Project: Cycloids • Section Project: Anamorphic Art • Connecting Parametric and Conics Activity: http://distance-ed.math.tamu.edu/Precalculus_home/Module5/Activity_5AB.pd
	Key Standards Covered	**Possible Resources**
Quarter 4 April 8- June 17	• EK 4.1A1: The *n*th partial sum is defined as the sum of the first *n*terms of a sequence. • EK 4.1A2: An infinite series of numbers converges to a real number *S* (or has sum *S*), if and only if the limit of its sequence of partial sums exists and equals *S*. • EK 4.1A3: Common series of numbers include geometric series, the harmonic series, and *p*-series. • EK 4.1A4: A series may be absolutely convergent, conditionally convergent, or divergent. • EK 4.1A5: If a series converges absolutely, then it converges. • EK 4.1A6: In addition to examining the limit of the sequence of partial sums, methods for determining whether a series of numbers converges or diverges are the *n*th term test, the comparison test, the limit comparison test, the integral test, the ratio test, and the alternating series test.	• Section Project: Cantor Disappearing Table • Section Project: Solera Method

<table>
<tr><td>Title of Unit</td><td>Differential Equations</td><td>Grade Level</td><td colspan="2">12th grade BC Calculus</td></tr>
<tr><td>Curriculum Area</td><td>AP Calculus</td><td>Time Frame</td><td colspan="2">5 weeks</td></tr>
<tr><td>Developed By</td><td colspan="4">Munira Jamali</td></tr>
<tr><td colspan="5">Identify Desired Results (Stage 1)</td></tr>
<tr><td colspan="5">Standards</td></tr>
<tr><td colspan="5">E.K.2.3F2: For differential equations, Euler's Method provides procedures for approximating a solution or a point on solution curve.
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<tr><td colspan="2">Overarching Understanding</td><td colspan="2">Overarching</td><td>Topical</td></tr>
<tr><td colspan="2">Areas between curves Volumes of revolution: disc, washer, and shell methods.
Volumes of geometric solids via cross-sections and integration;
Cavalieri's principle. Derivations of volumes of cone, pyramid, sphere, etc. via above techniques.
Arc length of a curve; surface area swept out by the graph of a function rotated about various axes.
Physics applications: work problems; pressure/force problems; center of mass of laminae of uniform thickness/density whose borders are defined in terms of two given functions.
More techniques of integration: substitution techniques; integration by parts; trig integrals; more trig substitution; partial fractions</td><td colspan="2" rowspan="2">· How can integrals be used to find areas and volumes of complex figures?
· What are the practical applications of finding such areas and volumes?
· What is about certain functions that lend themselves naturally to one method but not another?</td><td rowspan="2">What are slope fields?
What is logistic growth and decay exponential model?
What operations are needed for separation of variables for differential equation?
How can you compare the graphs of piecewise, absolute value, and composite functions?</td></tr>
<tr><td colspan="2">Related Misconceptions</td></tr>
</table>

To determine whether or not the limit exists as *x* approaches 0, a student would most likely use the definition of the existence of a limit at a point. This definition states that the limit of a function *f*(*x*)
as *x* approaches *c* exists if and only if both one-sided limits exist and are equal to some number, *L*. When a student sees a limit expression equal to infinity, such as x0f(x)=, it's only natural to jump to the conclusion that the limit exists since the function approaches the same value, infinity, from both sides. In doing so, these students incorrectly interpret infinity to represent this numerical value, *L*. Infinity can describe the behavior of a function at a point, but infinity is not a number technically, so the limit at that point does not exist.

As previously mentioned, some students are frightened by calculus because of its unfamiliar and potentially confusing notation. This influx of new symbols and mathematical language in such a short time creates opportunities for incorrect or improper uses of notation, ranging from dropping the constant of integration when evaluating indefinite integrals to misusing when differentiating. While these might seem like relatively minor mistakes or omissions to students, including these errors when presenting a solution can change the whole meaning of the problem. Remind students that using the appropriate notation when solving a problem step by step is just as important as arriving at a correct answer.

Knowledge Students will know…	**Skills** Students will be able to…

<table>
<tr><td colspan="2">To calculate Slope Fields and Euler Method
To calculate differential Equations Growth and Decay
Separation of Variables and Logistic Equations</td><td>To set up and solve (via techniques of integration or numerical integration/calculator) integrals associated with area, volume, arc length, and surface area problems, as well as a variety of physics applications.
To explain the difference between the disc, washer, and shell methods.
To determine which method is preferred in particular cases and explain why only one method will work in certain cases. Students will integrate a wide range of functions, require a broad spectrum of techniques.
Solve varied problems involving logistic growth.</td></tr>
<tr><td colspan="3">Assessment Evidence (Stage 2)</td></tr>
<tr><td colspan="3">Performance Task Description</td></tr>
<tr><td>Goal
Role
Audience
Situation
Product/Performance
Standards</td><td colspan="2">Section Project: Weight Loss</td></tr>
<tr><td colspan="3">Other Evidence</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Learning Plan (Stage 3)</td></tr>
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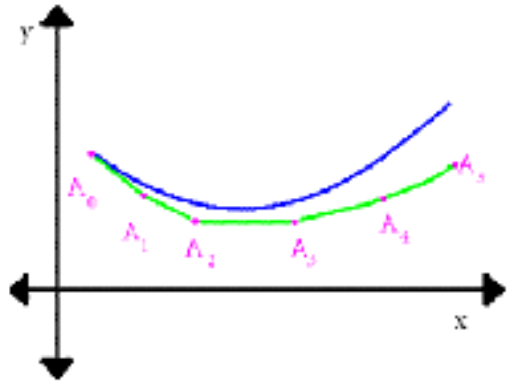
- **Where** are your students headed? Where have they been? How will you make sure the students know where they are going?
- How will you **hook** students at the beginning of the unit?
- What events will help students **experience and explore** the big idea and questions in the unit? How will you equip them with needed skills and knowledge?
- How will you cause students to **reflect and rethink?** How will you guide them in rehearsing, revising, and refining their work?
- How will you help students to **exhibit and self-evaluate** their growing skills, knowledge, and understanding throughout the unit?
- How will you **tailor** and otherwise personalize the learning plan to optimize the engagement and effectiveness of ALL students, without compromising the goals of the unit?
- How will you **organize** and sequence the learning activities to optimize the engagement and achievement of ALL students?

Euler's Method provides us with an *approximation* for the solution of a differential equation. The idea behind Euler's Method is to use the concept of *local linearity* to join multiple small line segments so that they make up an approximation of the actual curve, as seen below.



Example:
The blue line shows the actual graph of a function.

The green curve is an approximation using Euler's method. It is the collection of line segments as a result of Euler's Method. Each time Euler method is used another point is created and thus another line segment.

Note: -Generally, the approximation gets less accurate the further you are away from the initial value.

-Better accuracy is achieved when the points in the approximation are closer together.

AP Tip - Your approximation is going to be above the actual curve if the function is *concave down* and below the actual curve if the function is *concave up*.

What are the three things needed in order to use Euler's method?

Initial point- You must be given a starting point (x_0,y_0)

Δx- You must be given the change in x or step size. You are either given the step size directly or given information to find it. For example, if you have to go from x=2 to x=2.6 using three equal step sizes. You know the step size is .2

*Remember- the smaller your Δx the better your approximation

The differential equation - You have to know the slope of each individual line segment so that you can find Δy.

Example 1

Using separable equations technique

Given $dydx=2(x-1)$and the point (1,0) is a point on the curve, find an equation in the form y = f(x) and use it to evaluate f(3).

Logistic Model

Logistic growth can be described with a logistic equation. The **logistic equation** is of

<table>
<tr><th>Title of Unit</th><td>Integration Techniques. L'Hopital's Rule, and Improper Integrals</td><th>Grade Level</th><td>12 th grade BC Calculus</td></tr>
<tr><th>Curriculum Area</th><td>AP Calculus</td><th>Time Frame</th><td>5 weeks</td></tr>
<tr><th>Developed By</th><td colspan="3">Munira Jamali</td></tr>
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<tr><td colspan="4">EK 3.3B4: Many functions do not have closed form antiderivatives.
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<tr><td>Use partial fraction decomposition as an integration technique. The ultimate goal is to decompose a fraction so we can integrate it.
If we integrate the product rule $(uv)' = u'v + uv'$ we obtain an integration rule called integration by parts. It is a powerful tool, which complements substitution. As a rule of thumb, always try first to simplify a function and integrate directly, then give substitution a first shot before trying integration by parts
Evaluate limits for indeterminate form.
Determine the convergence of improper integrals</td><td rowspan="3">How does integration by parts work?
What are three integration formula should I expect?</td><td rowspan="3">How do I decide which is 'u' and 'v' for integration by parts?
How do I find coefficient for partial fractions?

What are the differences between the models and graphs of exponential growth and exponential decay?</td></tr>
<tr><th>Related Misconceptions</th></tr>
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Before actually starting to do partial fraction expansion, take a quick look at your integrand and make sure that the highest power in the denominator is larger than the highest power in the numerator. If it isn't, you need to do long division of polynomials or synthetic division to reduce the power in the numerator. This will often make the integral much easier to evaluate before doing any partial fraction expansion. Some problems that do not look like they are candidates for partial fractions may be able to be converted to partial fraction form using substitution. You will often see them when you have ex terms. For integral for parts, choosing the right 'u' and 'v' are critical. If the problems are not solved within one minute then wrong parts were chosen. AP test rule !!		

Knowledge Students will know…	**Skills** Students will be able to…
rewrite a fraction into simpler (partial) fractions to find its integral To find integral of trig function using substitution To find integral by using integral by parts formula. 1. Evaluate limits for indeterminate form. 2. Determine the convergence of improper integrals	Decompose mixed algebraic function into partial fraction components Use integral Trig Substitution To apply integral by parts formula. Use limits to evaluate improper integrals. Use the Direct Comparison Test and the Limit Comparison Test to determine the convergence or divergence of improper integrals

Assessment Evidence (Stage 2)
Performance Task Description

• **Goal** • **Role** • **Audience** • **Situation** • **Product/Performance** • **Standards**	Section Project : Power Lines
Other Evidence	
Learning Plan (Stage 3)	

- Where are your students headed? Where have they been? How will you make sure the students know where they are going?
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Integration Technique - Trigonometric Substitution
The key to using this technique is to recognize specific sets of terms in the integrand, which will tell you the associated substitution. Table one contains a summary.

TABLE ONE - LIST OF FACTORS

	integrand	*substitution*	*identity*
tangent	x2+a2x2+a2	x=atan(θ)x=atan(θ)	1+tan2(θ)=sec2(θ)1+tan2(θ)=sec2(θ)
sine	−x2+a2−x2+a2	x=asin(θ)x=asin(θ)	sin2(θ)+cos2(θ)=1sin2(θ)+cos2(θ)=1
secant	x2−a2x2−a2	x=asec(θ)x=asec(θ)	1+tan2(θ)=sec2(θ)1+tan2(θ)=sec2(θ)

a is a constant; *x* and *θ* are variables

The terms you are looking for in the integrand may appear exactly as they are listed in table one or, more likely, they will be embedded in the integrand, like under a square root or with a power. They can appear in the numerator or the denominator of a fraction. Sometimes you may even have to complete the square in order to see the term in this form. In any case, once you have recognized the form of the term, you can choose the correct the substitution. Here are the steps to evaluate integrals using this technique.

1. Choose a substitution from table one depending on the term that appears in the integrand.
2. Draw a triangle based on the substitution.
3. Perform the substitution in the integral, simplify and evaluate.
4. Use the triangle from step 2 to convert your answer back to the original variable.

Integration Using Partial Fractions

The idea of using partial fractions to integrate is to convert the integrand into a form that we can integrate using techniques we've learned so far. As you know by now, integration is much more difficult that differentiation. When we have a fraction with polynomials in the denominator that can be factored, we can sometimes separate the fraction into two or more fractions that we use substitution or another known technique to integrate.

Integration by parts

Functions often arise as products of other functions, and we may be required to integrate these products. For example, we may be asked to determine

$$\int x \cos x dx$$

Here, the integrand is the product of the functions x and cos x. A rule exists for integrating products of functions and in the following section we will derive.

Title of Unit	**Conics , Parametric Equations and Polar Coordinates**	**Grade Level**	12th Grade BC Curriculum
Curriculum Area	AP Calculus	**Time Frame**	5 weeks
Developed By	Munira Jamali		

Identify Desired Results (Stage 1)
Content Standards
LO 3.4C: Apply definite integrals to problems involving motion. **LO 3.4D:** Apply definite integrals to problems involving area, volume, (**BC**) and length of a curve. **EK 3.4C1: (BC)** The definite integral can be used to determine displacement, distance, and position of a particle moving along a curve given by parametric or vector-valued functions. **EK 3.4D1:** Areas of certain regions in the plane can be calculated with definite integrals. **(BC)** Areas bounded by polar curves can be calculated with definite integrals.

Understandings	Essential Questions	
Overarching Understanding	**Overarching**	**Topical**

Limits are the underlying concept supporting physical applications that are embedded in many fields. At the conclusion of this unit, students will be able to: 1. Use parametric equations to analyze motion with velocity and acceleration vectors. 2. Find areas of regions defined by polar equation Forces and combinations of forces that act upon objects can be mathematically modeled. Some relations which are not functions can be more easily graphed using the polar coordinate system. There are many ways to solve problems, but some are more efficient than others. • Representing a situation in multiple ways leads to better understanding and more effective communication. • Different representations are appropriate at different times and influence the interpretation	How do we determine which representation is the most appropriate? • What are the benefits of different representations? • In what ways does a particular representation simplify problem solving?	What is the relationship between the six trigonometric functions, their graphs, and the unit circle?
Related Misconceptions		

To determine whether or not the limit exists as *x* approaches 0, a student would most likely use the definition of the existence of a limit at a point. This definition states that the limit of a function *f*(*x*) as *x* approaches *c* exists if and only if both one-sided limits exist and are equal to some number, *L*. When a student sees a limit expression equal to infinity, such as x0f(x)=, it’s only natural to jump to the conclusion that the limit exists since the function approaches the same value, infinity, from both sides. In doing so, these students incorrectly interpret infinity to represent this numerical value, *L*. Infinity can describe the behavior of a function at a point, but infinity is not a number technically, so the limit at that point does not exist.

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Knowledge Students will know…	**Skills** Students will be able to…

<table>
<tr><td colspan="2">To work with the polar coordinate system, convert from rectangular to polar coordinates and vice versa, use vectors and solve applied problems with vectors, and work with parametric equations and understand the advantages of parametric representations.</td><td>Evaluate sets of parametric equations for given values of the parameter
• Convert parametric equations to rectangular form eliminating the parameter
• Create a parametric equation set from a rectangular equations
• Sketch/graph parametric equations
• Solve problems using parametric equations
• Plot polar coordinates
• Convert between polar and rectangular equation forms
• Sketch/graph basic polar equations
• Identify basic polar equations such as rose, cardioid, limacons, and lemniscates
• Determine which representation (parametric, polar, or rectangular) is most appropriate for solving a particular problem</td></tr>
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Parametric equations and vectors were first studied and developed in a pre-calculus course. In fact, many schools do just that. It would be nice if students knew all about these topics when they started BC calculus. Because of time considerations, this very rich topic is not fully developed in BC calculus. That said, the parametric/vector equation questions only concern motion in a plane.

Another concern is that most calculus textbooks jump right to vectors in 3-space while the exam only tests motion in a plane and 2-dimensional vectors. (Actually, the equations and ideas are the same with an extra variable for the z-direction) In the plane, the **position** of a moving object as a function of time, t, can be specified by a pair of parametric equations $x = x(t)$ and $y = y(t)$ or the equivalent vector $\langle x(t), y(t)\rangle$. The **path** is the curve traced by the parametric equations or the tips of the position vector. . The **velocity** of the movement in the x- and y-direction is given by the vector $\langle x'(t), y'(t)\rangle$. The vector sum of the components gives the direction of motion. Attached to the tip of the position vector this vector is tangent to the path pointing in the direction of motion.The length of this vector is the **speed** of the moving object. $\text{Speed} = \sqrt{(x'(t))^2 + (y'(t))^2}$. (Notice that this is the same as the speed of a particle moving on the number line with one less parameter: On the number line $\text{Speed} = |v| = \sqrt{(x'(t))^2}$.)

The **acceleration** is given by the vector $\langle x''(t), y''(t)\rangle$.

What students should know how to do:

- Vectors may be written using parentheses, ( ), or pointed brackets, $\langle\rangle$, or even $\vec{i}, \vec{j}$ form. The pointed brackets seem to be the most popular right now, but all common notations are allowed and will be recognized by readers.
- Find the speed at time t: $\text{Speed} = \sqrt{(x'(t))^2 + (y'(t))^2}$
- Use the definite integral for arc length to find the distance traveled . Notice that this is the integral of the speed (rate times time = distance).
- The slope of the path is $\frac{dy}{dx} = \frac{y'(t)}{x'(t)}$. See this post for more on finding the first and second derivatives with respect to x.
- Determine when the particle is moving left or right,
- Determine when the particle is moving up or down,
- Find the extreme position (farthest left, right, up, down, or distance from the origin).
- Given the position find the velocity by differentiating; given the velocity find the acceleration by differentiating.

Title of Unit	**Infinite Series**	**Grade Level**	12th grade Calculus BC
Curriculum Area	AP Calculus	**Time Frame**	6 weeks
Developed By	Munira Jamali		
Identify Desired Results (Stage 1)			
Content Standards			

EK 4.1A1: The *n*th partial sum is defined as the sum of the first *n*terms of a sequence.

EK 4.1A2: An infinite series of numbers converges to a real number *S* (or has sum *S*), if and only if the limit of its sequence of partial sums exists and equals *S*.

EK 4.1A3: Common series of numbers include geometric series, the harmonic series, and *p*-series.

EK 4.1A4: A series may be absolutely convergent, conditionally convergent, or divergent.

EK 4.1A5: If a series converges absolutely, then it converges.

EK 4.1A6: In addition to examining the limit of the sequence of partial sums, methods for determining whether a series of numbers converges or diverges are the *n*th term test, the comparison test, the limit comparison test, the integral test, the ratio test, and the alternating series test.

Understandings	Essential Questions	
Overarching Understanding	**Overarching**	**Topical**
Mathematical induction is a valid form of proof for sequence-type problems. - Sequence and series formulas are common-sense shortcuts. - Some infinite series converge.	What is proof? How could the sum of an infinite number of numbers possibly converge?	How does one identify and find an inverse of a function?
Related Misconceptions		

To determine whether or not the limit exists as *x* approaches 0, a student would most likely use the definition of the existence of a limit at a point. This definition states that the limit of a function *f*(*x*)
as *x* approaches *c* exists if and only if both one-sided limits exist and are equal to some number, *L*. When a student sees a limit expression equal to infinity, such as x0f(x)=, it's only natural to jump to the conclusion that the limit exists since the function approaches the same value, infinity, from both sides. In doing so, these students incorrectly interpret infinity to represent this numerical value, *L*. Infinity can describe the behavior of a function at a point, but infinity is not a number technically, so the limit at that point does not exist.

As previously mentioned, some students are frightened by calculus because of its unfamiliar and potentially confusing notation. This influx of new symbols and mathematical language in such a short time creates opportunities for incorrect or improper uses of notation, ranging from dropping the constant of integration when evaluating indefinite integrals to misusing when differentiating. While these might seem like relatively minor mistakes or omissions to students, including these errors when presenting a solution can change the whole meaning of the problem. Remind students that using the appropriate notation when solving a problem step by step is just as important as arriving at a correct answer.

Knowledge
Students will know…

Skills
Students will be able to…

Power series are important tools for approximating and defining functions. At the conclusion of this unit, students will be able to: 1. Represent functions using Taylor Series. 2. Determine the interval of convergence. 3. Estimate the error bound when evaluating a function with a Taylor Polynomial.	Identify Sequences and Series • Find Partial Sums of a given Series. • Find the terms, partial sums, infinite sums, or n in a geometric sequence. • Determine the convergence or divergence of a sequence. • Determine the divergence of a series. • Use the Comparison Tests to check for convergence or divergence. • Use the Integral Test to check for convergence or divergence. • Use the Ratio and Nth Root Tests to check for convergence or divergence. • Use the Alternating Series Test to check for convergence or divergence

Assessment Evidence (Stage 2)	
Performance Task Description	
• **Goal** • **Role** • **Audience** • **Situation** • **Product/Performance** • **Standards**	**Section Project: Cantor Disappearing Table** Section Project: Solera Method
Other Evidence	
Learning Plan (Stage 3)	

• **Where are your students headed? Where have they been? How will you make sure the students know where they are going?** • **How will you hook students at the beginning of the unit?** • **What events will help students experience and explore the big idea and questions in the unit? How will you equip them with needed skills and knowledge?** • **How will you cause students to reflect and rethink? How will you guide them in rehearsing, revising, and refining their work?** • **How will you help students to exhibit and self-evaluate their growing skills, knowledge, and understanding throughout the unit?** • **How will you tailor and otherwise personalize the learning plan to optimize the engagement and effectiveness of ALL students, without compromising the goals of the unit?** • **How will you organize and sequence the learning activities to optimize the engagement and achievement of ALL students?**	Students will start the chapter off with a brief discussion of sequences. This section will focus on the basic terminology and convergence of sequences More on Sequences – Here we will take a quick look about monotonic and bounded sequences. Series – The Basics – In this section we will discuss some of the basics of infinite series. Series – Convergence/Divergence – Most of this chapter will be about the convergence/ divergence of a series so we will give the basic ideas and definitions in this section. © 2007 Paul Dawkins iii http://tutorial.math.lamar.edu/terms.aspx Calculus II Series – Special Series – We will look at the Geometric Series, Telescoping Series, and Harmonic Series in this section. Integral Test – Using the Integral Test to determine if a series converges or diverges. Comparison Test/Limit Comparison Test – Using the Comparison Test and Limit Comparison Tests to determine if a series converges or diverges. Alternating Series Test – Using the Alternating Series Test to determine if a series converges or diverges. Absolute Convergence – A brief discussion on absolute convergence and how it differs from convergence. Ratio Test – Using the Ratio Test to determine if a series converges or diverges. Root Test – Using the Root Test to determine if a series converges or diverges. Strategy for Series – A set of general guidelines to use when deciding which test to use. Estimating the Value of a Series – Here we will look at estimating the value of an infinite series. Power Series – An introduction to power series and some of the basic concepts. Power Series and Functions – In this section we will start looking at how to find a power series representation of a function. Taylor Series – Here we will discuss how to find the Taylor/Maclaurin Series for a function. Applications of Series – In this section we will take a quick look at a couple of applications of series. Binomial Series – A brief look at binomial series.