= 0 ° , when the distance reaches a minimum , then gradually increases again to infinity at ?1 ? ?0 =
90 ° . The minimum distance b is the impact parameter , which is defined as the length of the perpendicular from the fixed center to the line of motion . The same radial motion is possible when an inverse @-@ cube central force is added .
An inverse @-@ cube central force F2 (r) has the form
<formula>
where the numerator ? may be positive (repulsive) or negative (attractive) . If such an inverse @-@ cube force is introduced , Newton 's theorem says that the corresponding solutions have a shape called Cotes 's spirals . These are curves defined by the equation
<formula>
where the constant k equals
<formula>
When the right @-@ hand side of the equation is a positive real number , the solution corresponds to an epispiral . When the argument ?1 ? ?0 equals ± 90 ° × k , the cosine goes to zero and the radius goes to infinity . Thus , when k is less than one , the range of allowed angles becomes small and the force is repulsive (red curve on right in Figure 7) . On the other hand , when k is greater than one , the range of allowed angles increases , corresponding to an attractive force (green , cyan and blue curves on left in Figure 7) ; the orbit of the particle can even wrap around the center several times . The possible values of the parameter k may range from zero to infinity , which corresponds to values of ? ranging from negative infinity up to the positive upper limit , L12 / m . Thus , for all attractive inverse @-@ cube forces (negative ?) there is a corresponding epispiral orbit , as for some repulsive ones (? < L12 / m) , as illustrated in Figure 7 . Stronger repulsive forces correspond to a faster linear motion .
One of the other solution types is given in terms of the hyperbolic cosine :
<formula>
where the constant ? satisfies
<formula>
This form of Cotes 's spirals corresponds to one of the two Poinsot 's spirals (Figure 8) . The possible values of ? range from zero to infinity , which corresponds to values of ? greater than the positive number L12 / m . Thus , Poinsot spiral motion only occurs for repulsive inverse @-@ cube central forces , and applies in the case that L is not too large for the given ? .
Taking the limit of k or ? going to zero yields the third form of a Cotes 's spiral , the so @-@ called reciprocal spiral or hyperbolic spiral , as a solution
<formula>
where A and ? are arbitrary constants . Such curves result when the strength ? of the repulsive force exactly balances the angular momentum @-@ mass term
<formula>

= = Closed orbits and inverse @-@ cube central forces = =