Hwk 3
—7 Feb 2011

Problem 1

The statement of the problem should have said that the force was that on a unit mass.
(a) Since the first term, $-G M_s R_{\text{es}}^{-2}$, does not have the mass of Earth, it cannot be the pull of Earth.

(b) Consider the tidal term, $+G M_s R_{\text{es}}^{-2}(2\, r / R_{\text{es}})$. The distance between the drop of water and the sun is $(R_{\text{es}} + r)$. On the side opposite the sun ($r > 0$), the tidal force is positive, which is opposite the pull of earth. On the sun-facing side ($r < 0$); again, the tidal force is opposite the pull of Earth. Therefore high tide occurs at noon and midnight.

Reality is more complicated. The tidal force of the moon also causes tides. Furthermore, water does not move instantaneously: the height of the water lags behind the force.

Problem 2

The tidal force at any place on Earth is

$$+2\, G\, M_s\, R_{\text{es}}^{-4}\, \vec{r} \cdot \overrightarrow{R_{\text{es}}},$$

where the positive direction is away from the sun. The vector $\vec{r}$ specifies the location on Earth.

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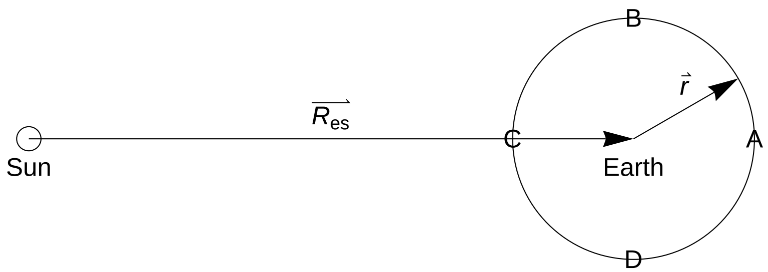
In[342]:= Graphics[{Circle[{-5, 0}, .1], Text["Sun", {-5, 0}, {0, 2}],
   Circle[{0, 0}, 1], , Arrow[{{-5, 0}, {0, 0}}],
   Text["R⃗es", {-2.5, 0}, {0, -1.5}], Text["Earth", {0, 0}, {0, 2}],
   {Text["r⃗", # / 2, {0, -1.5}], Arrow@{{0, 0}, #}} &[{Cos[30 °], Sin[30 °]}],
   Text[#[[1]], {Cos[#[[2]] °], Sin[#[[2]] °]}] & /@
    {{"A", 0}, {"B", 90}, {"C", 180}, {"D", 270}}},
  BaseStyle → {FontSize → Medium, FontFamily → "Helvetica"}]
```

Out[342]=



(a, b) The dot product is $r\, R_{\text{es}} \cos\theta$, where θ is the angle between $\vec{r}$ and $\overrightarrow{R_{\text{es}}}$. The tidal force is big at A and C. The tidal for is zero at B and D, where $\vec{r}$ and $\overrightarrow{R_{\text{es}}}$ are perpendicular.

In[349]:=
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Plot[Cos[θ °], {θ, 0, 360}, AxesLabel → {"θ [deg]", "Ftidal/Ftidal(0)"}, Epilog →
  {Text[#[[1]], {#[[2]], Cos[#[[2]] °]}] & /@ {{"A", 0}, {"B", 90}, {"C", 180}, {"D", 270}}},
 BaseStyle → {FontSize → Medium, FontFamily → "Helvetica"}]
```
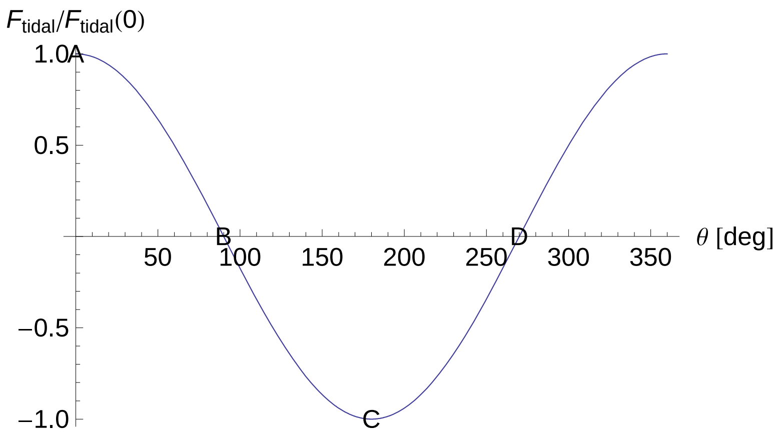

Out[349]=



Problem 3

For the moon to be spherical, gravity is holding it together, yet it is inside the Roche limit for the case where Jupiter and the moon have the same density. The Roche limit must be smaller. Therefore the density of the moon must be higher than the density of Jupiter by at least

In[350]:=
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169 / 150.
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Out[350]= 1.12667