Info:

- Room assignments are linked on course webpage. Go to the right room 15 minutes early.
- There is no curve on any of our exams.

Strategy:

- Read the whole exam before you start and do the easy ones first.
- Don’t “equation hunt” - there are “distractors”.
- You can get partial credit on the 5 part questions...
Partial Credit

Suppose this is a 5 answer question and you bubble

- Answer A (correct)
- Answer B (wrong)
- Answer C (wrong)
- Answer D (wrong)
- Answer E (wrong)

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6 3 2 0 0
```

For the 3 answer questions you can only mark one choice!

- Answer A (correct)
- Answer B (wrong)
- Answer C (wrong)

```
3 0 0
```
How this review will work:

• We will move fast (~2 minutes/problem)

• I’ll give you a hint (if needed)

• You will discuss with your neighbor and vote again

• I will summarize

• Working from the Fall 2017 Exam #1 (version B)
The next three questions pertain to the situation described below.

A physics student is trying to pull a box of books of mass $m = 45$ kg across the floor as shown in the figure. The coefficient of static friction $\mu_s = 0.42$ and the coefficient of kinetic friction $\mu_k = 0.3$.

1) If the student pulls horizontally ($\theta = 0^\circ$), the normal force $N$ is

a. $N = mg$
b. $N < mg$
c. $N > mg$
The next three questions pertain to the situation described below.

\[
\begin{align*}
\begin{cases}
\vec{F} = 0 = -mg\hat{y} + N\hat{z} \\
\end{cases}
\end{align*}
\]

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1) If the student pulls horizontally (\( \theta = 0^\circ \)), the normal force \( N \) is

a. \( N = mg \)

b. \( N < mg \)

c. \( N > mg \)

\[
|N| = |mg - T|.
\]
The next three questions pertain to the situation described below.

A physics student is trying to pull a box of books of mass \( m = 45 \text{ kg} \) across the floor as shown in the figure. The coefficient of static friction \( \mu_s = 0.42 \) and the coefficient of kinetic friction \( \mu_k = 0.3 \).

2) The box is originally at rest and the student pulls at an angle \( \theta = 27^\circ \). What is the minimum tension, \( T \), required to start the box moving?

a. \( T_{\text{min}} = 208 \text{ N} \)
b. \( T_{\text{min}} = 129 \text{ N} \)
c. \( T_{\text{min}} = 408 \text{ N} \)
d. \( T_{\text{min}} = 156 \text{ N} \)
e. \( T_{\text{min}} = 171 \text{ N} \)
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a. $T_{\text{min}} = 208$ N  
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c. $T_{\text{min}} = 408$ N  
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e. $T_{\text{min}} = 171$ N
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A physics student is trying to pull a box of books of mass $m = 45$ kg across the floor as shown in the figure. The coefficient of static friction $\mu_s = 0.42$ and the coefficient of kinetic friction $\mu_k = 0.3$.

3) If the student applies the minimum force required get the box moving for a period of 5 seconds. Which of the following best describes the motion of the box?

- a. The velocity of the box will continue to increase over the 5 seconds.
- b. The box will continue to move at a constant speed for the 5 seconds.
- c. The box will start moving, but then slow down to a stop during the 5 seconds.

$$F_{\text{net}} = F_{\text{app}} - F_x = ma_{\text{net}}$$

$$v_x = v_{0x} + a_{\text{net}}t$$
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3) If the student applies the minimum force required get the box moving for a period of 5 seconds. Which of the following best describes the motion of the box?

a. The velocity of the box will continue to increase over the 5 seconds.

b. The box will continue to move at a constant speed for the 5 seconds.

c. The box will start moving, but then slow down to a stop during the 5 seconds.
The next three questions pertain to the situation described below.

An empty car is driven off of a cliff as part of a stunt for a new movie. The car starts at rest and then undergoes a constant acceleration of \( a = 6 \text{ m/s}^2 \) for a distance \( r = 100 \text{ m} \). The car then goes off the cliff, leaving the cliff travelling parallel to the ground. The cliff is a height \( h = 75 \text{ m} \) above the ground below. (As usual, we will neglect air resistance.)

4) Which of the following is a valid expression for the time the car is in the air?

a. \( t = \sqrt{\frac{hr}{Dg}} \)

b. \( t = \frac{h}{g} \)

c. \( t = \sqrt{\frac{2h}{g}} \)

d. \( t = \sqrt{hr/Dg} \)

e. \( t = hr/Dg \)

\[
y(t^*) = y_0 + \frac{1}{2} a t^2 + \frac{1}{2} g t^2 = 0
\]

\[
h = \frac{1}{2} g t^2
\]

\[
t^* = \sqrt{\frac{2h}{g}}
\]
The next three questions pertain to the situation described below.

An empty car is driven off of a cliff as part of a stunt for a new movie. The car starts at rest and then undergoes a constant acceleration of $a = 6 \text{ m/s}^2$ for a distance $r = 100$ m. The car then goes off the cliff, leaving the cliff travelling parallel to the ground. The cliff is a height $h = 75$ m above the ground below. (As usual, we will neglect air resistance.)

4) Which of the following is a valid expression for the time the car is in the air?

a. $t = \sqrt{\frac{h}{a/g^2}}$

b. $t = \frac{h}{a}$

c. $t = \sqrt{2h/g}$

d. $t = \sqrt{hr/Dg}$

e. $t = hr/Dg$
The next three questions pertain to the situation described below.

An empty car is driven off of a cliff as part of a stunt for a new movie. The car starts at rest and then undergoes a constant acceleration of $a = 6 \text{ m/s}^2$ for a distance $r = 100$ m. The car then goes off the cliff, leaving the cliff travelling parallel to the ground. The cliff is a height $h = 75$ m above the ground below. (As usual, we will neglect air resistance.)

\[ v = \sqrt{v_x^2 + 2y^2} \]

5) What is the speed of the car just before it hits the ground?

\[ \Delta KE = W_{\text{tot}} \]
\[ \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \int_{x_i}^{x_f} F_{\text{for}} \cdot \mathbf{r} + mgh \]
\[ \int_{v_i}^{v_f} = \frac{1}{2}ma \]
\[ \frac{1}{2}mv_f^2 = W_{\text{for}} + Wh \]
\[ v_f = \sqrt{2ar + 2gh} \]

a. $v_{\text{impact}} = 73 \text{ m/s}$
b. $v_{\text{impact}} = 27.1 \text{ m/s}$
c. $v_{\text{impact}} = 34.6 \text{ m/s}$
d. $v_{\text{impact}} = 51.7 \text{ m/s}$
e. $v_{\text{impact}} = 3.72 \text{ m/s}$
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6) If the initial acceleration of the car was doubled ($a_2 = 12 \text{ m/s}^2$), how would the new distance the car lands from the cliff, $D_2$ compare to the original distance $D$?

a. $D_2 = \sqrt{2}D$

b. $D_2 = 4D$

c. $D_2 = 2D$
The next three questions pertain to the situation described below.

An empty car is driven off of a cliff as part of a stunt for a new movie. The car starts at rest and then undergoes a constant acceleration of $a = 6 \text{ m/s}^2$ for a distance $r = 100$ m. The car then goes off the cliff, leaving the cliff travelling parallel to the ground. The cliff is a height $h = 75 \text{ m}$ above the ground below. (As usual, we will neglect air resistance.)

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a. $D_2 = \sqrt{2}D$

b. $D_2 = 4D$

c. $D_2 = 2D$
The next three questions pertain to the situation described below.

A particle is subject to a force \( F \) that is changing in time. The figure shows the \( x \)-coordinate of that particle's position as a function of time. The trajectory of the particle is divided into three regions as indicated in the figure.

7) Which of the following correctly describes \( \bar{F}_x \), the average value of the \( x \)-component of the force in region I?

a. \( \bar{F}_x > 0 \)

b. \( \bar{F}_x < 0 \)

c. \( \bar{F}_x = 0 \)

\[
\bar{a} = \frac{\bar{d^2x}}{\bar{dt}^2} > 0
\]

\[
F - ma - m \frac{d^2x}{dt^2} > 0
\]
A particle is subject to a force \( F \) that is changing in time. The figure shows the \( x \)-coordinate of that particle's position as a function of time. The trajectory of the particle is divided into three regions as indicated in the figure.

7) Which of the following correctly describes \( F_x \), the average value of the \( x \)-component of the force in region \( I \)?

- a. \( F_x > 0 \)
- b. \( F_x < 0 \)
- c. \( F_x = 0 \)
The next three questions pertain to the situation described below.

A particle is subject to a force $F$ that is changing in time. The figure shows the $x$-coordinate of that particle's position as a function of time. The trajectory of the particle is divided into three regions as indicated in the figure.

8) In region $II$, the particle’s speed is

a. constant.

b. decreasing.

c. increasing.
The next three questions pertain to the situation described below.

A particle is subject to a force \( F \) that is changing in time. The figure shows the \( x \)-coordinate of that particle's position as a function of time. The trajectory of the particle is divided into three regions as indicated in the figure.

8) In region \( II \), the particle’s speed is

a. constant
b. decreasing.

8) In region \( II \), the particle’s speed is

a. constant
b. decreasing.
c. increasing.
The next three questions pertain to the situation described below.

A particle is subject to a force $F$ that is changing in time. The figure shows the $x$-coordinate of that particle's position as a function of time. The trajectory of the particle is divided into three regions as indicated in the figure.

9) In region III, which of the following applies to the $x$-component of the particle's velocity

a. $v_x > 0$

b. $v_x < 0$

c. $v_x = 0$
The next three questions pertain to the situation described below.

A particle is subject to a force $F$ that is changing in time. The figure shows the $x$-coordinate of that particle's position as a function of time. The trajectory of the particle is divided into three regions as indicated in the figure.

9) In region $III$, which of the following applies to the $x$-component of the particle’s velocity

a. $v_x > 0$

b. $v_x < 0$

b. $v_x = 0$
An inclined plane with angle $\theta$ has a rough top surface with coefficient of static friction $\mu_s$ and kinetic friction $\mu_k$. A mass, $m$, sits at rest with respect to the plane and is attached by an ideal string over a massless pulley to a hanging mass, $M$.

\[ Mg = mgsin\theta + \mu_s N \]

10) Which of the following is the correct expression for the maximum value of the hanging mass, $M_{\text{max}}$, such that the mass, $m$, remains stationary on the plane?

a. $M_{\text{max}} = m(sin\theta + \mu_s\cos\theta )$

b. $M_{\text{max}} = m \mu_s \tan \theta$

c. $M_{\text{max}} = m \sin \theta$

d. $M_{\text{max}} = m(sin\theta - \mu_s\cos\theta )$

e. $M_{\text{max}} = m(\tan \theta + \mu_s)$
An inclined plane with angle $\theta$ has a rough top surface with coefficient of static friction $\mu_s$ and kinetic friction $\mu_k$. A mass, $m$, sits at rest with respect to the plane and is attached by an ideal string over a massless pulley to a hanging mass, $M$.

10) Which of the following is the correct expression for the maximum value of the hanging mass, $M_{\text{max}}$, such that the mass, $m$, remains stationary on the plane?

- a. $M_{\text{max}} = m(\sin\theta + \mu_s\cos\theta)$
- b. $M_{\text{max}} = m\mu_s\tan\theta$
- c. $M_{\text{max}} = m\sin\theta$
- d. $M_{\text{max}} = m(\sin\theta - \mu_s\cos\theta)$
- e. $M_{\text{max}} = m(\tan\theta + \mu_s)$
Fall ’17 – Question 11

The next two questions pertain to the situation described below.

An inclined plane with angle $\theta$ has a rough top surface with coefficient of static friction $\mu_s$ and kinetic friction $\mu_k$. A mass, $m$, sits at rest with respect to the plane and is attached by an ideal string over a massless pulley to a hanging mass, $M$.

11) The string is suddenly cut and the mass $m$ begins to slide down the plane with an acceleration, $a$. What is the correct expression for $\mu_k$?

- a. $\mu_k = (mg \sin \theta - a) / \cos \theta$
- b. $\mu_k = (a + gt \tan \theta) / \cos \theta$
- c. $\mu_k = (g \sin \theta - a) / (g \cos \theta)$
- d. $\mu_k = \tan \theta$
- e. $\mu_k = \arctan \theta / g$

The correct answer is a. $\mu_k = (mg \sin \theta - a) / \cos \theta$. The net force is $F_{net} = ma = mg \sin \theta - \mu_N$, where $\mu_N$ is the normal force.

$M_k = \frac{g \sin \theta - a}{g \cos \theta}$
An inclined plane with angle $\theta$ has a rough top surface with coefficient of static friction $\mu_s$ and kinetic friction $\mu_k$. A mass, $m$, sits at rest with respect to the plane and is attached by an ideal string over a massless pulley to a hanging mass, $M$.

11) The string is suddenly cut and the mass $m$ begins to slide down the plane with an acceleration, $a$. What is the correct expression for $\mu_k$?

- a. $\mu_k = (mg \sin \theta - a) / \cos \theta$
- b. $\mu_k = (a + g \tan \theta) / \cos \theta$
- c. $\mu_k = (gs \sin \theta - a) / (g \cos \theta)$
- d. $\mu_k = \tan \theta$
- e. $\mu_k = a \tan \theta / g$
The next three questions pertain to the situation described below.

A 8 kg block starts at rest and slides down a frictionless ramp that makes an angle $\theta = 26$ degrees with respect to the horizontal floor below. At the bottom of the ramp, after having slid a distance $D_1$, the speed of the block is observed to be 12 m/s.

12) What is the distance $D_1$ that the block slid along the ramp?

- a. $D_1 = 7.35$ m
- b. $D_1 = 14.7$ m
- c. $D_1 = 8.17$ m
- d. $D_1 = 12.5$ m
- e. $D_1 = 16.8$ m
The next three questions pertain to the situation described below.

A 8 kg block starts at rest and slides down a frictionless ramp that makes an angle $\theta=26$ degrees with respect to the horizontal floor below. At the bottom of the ramp, after having slid a distance $D_1$, the speed of the block is observed to be 12 m/s.

12) What is the distance $D_1$ that the block slid along the ramp?

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The next three questions pertain to the situation described below.

A 8 kg block starts at rest and slides down a frictionless ramp that makes an angle $\theta=26$ degrees with respect to the horizontal floor below. At the bottom of the ramp, after having slid a distance $D_1$, the speed of the block is observed to be 12 m/s.

13) After reaching the bottom of the ramp, the block slides onto the horizontal floor with the initial speed of 12 m/s. The coefficient of kinetic friction between the block and the floor $\mu_k=0.3$. From the moment it reaches the floor, how much time does it take the block to stop?

a. $t = 1.2$ s  
b. $t = 40$ s  
c. $t = 4.1$ s  
d. $t = 9.8$ s  
e. $t = 33$ s
The next three questions pertain to the situation described below.

A 8 kg block starts at rest and slides down a frictionless ramp that makes an angle $\theta=26$ degrees with respect to the horizontal floor below. At the bottom of the ramp, after having slid a distance $D_1$, the speed of the block is observed to be 12 m/s.

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- e. $t = 33$ s
The next three questions pertain to the situation described below.

A 8 kg block starts at rest and slides down a frictionless ramp that makes an angle $\theta=26$ degrees with respect to the horizontal floor below. At the bottom of the ramp, after having slid a distance $D_1$, the speed of the block is observed to be 12 m/s.

14) If the mass of the block in the above problem were doubled, the time required for the block to come to a complete stop would

a. decrease.
b. increase.
c. stay the same.
A 8 kg block starts at rest and slides down a frictionless ramp that makes an angle $\theta = 26$ degrees with respect to the horizontal floor below. At the bottom of the ramp, after having slid a distance $D_1$, the speed of the block is observed to be 12 m/s.

14) If the mass of the block in the above problem were doubled, the time required for the block to come to a complete stop would

a. decrease.
b. increase.
c. stay the same.
Fall ’17 – Question 15

A rocket is drifting in deep space where gravitational forces are negligible. The rocket is initially drifting sideways (x direction) with its engine off as shown above. The engine, which generates a constant force in the -y direction, is then turned on (corresponding to point I) for 4 seconds, and then turned off again (point II).

15) Which of the diagrams above best represents the path of the rocket?

- a. 1
- b. 2
- c. 3

\[ y = y_0 + \frac{1}{2} a t^2 \]
A rocket is drifting in deep space where gravitational forces are negligible. The rocket is initially drifting sideways (x direction) with its engine off as shown above. The engine, which generates a constant force in the -y direction, is then turned on (corresponding to point I) for 4 seconds, and then turned off again (point II).

15) Which of the diagrams above best represents the path of the rocket?

- a. 1
- b. 2
- c. 3
16) An inclined plane makes an angle $\theta$ with respect to horizontal. A box sits at rest on the ramp, held in place only by friction. The magnitude of the frictional force exerted by the ramp on the box is:

a. $\mu mg$

b. $mg \sin \theta$

c. $\mu mg \cos \theta$
16) An inclined plane makes an angle $\theta$ with respect to horizontal. A box sits at rest on the ramp, held in place only by friction. The magnitude of the frictional force exerted by the ramp on the box is:

a. $\mu mg$

b. $mg \sin \theta$

c. $\mu mg \cos \theta$
A metal bucket with mass 1.5 kg containing water of mass 3 kg is swung in a vertical circle of radius $r = 0.85$ m using a massless rope as shown in the figure. The tangential speed of the water bucket varies around the circle, but is such that at the top of the circle the tangential speed is just high enough to keep the bucket moving in a circular path.

17) The weight of the \{bucket + water\} and the tension in the rope when the bucket is at the top of the circle, $T_{\text{top}}$, form a Newton’s 3rd Law action/reaction pair.

a. True
b. False
A metal bucket with mass 1.5 kg containing water of mass 3 kg is swung in a vertical circle of radius $r = 0.85$ m using a massless rope as shown in the figure. The tangential speed of the water bucket varies around the circle, but is such that at the top of the circle the tangential speed is just high enough to keep the bucket moving in a circular path.

17) The weight of the \{bucket + water\} and the tension in the rope when the bucket is at the top of the circle, $T_{\text{top}}$, form a Newton’s 3rd Law action/reaction pair.

a. True
b. False
A metal bucket with mass 1.5 kg containing water of mass 3 kg is swung in a vertical circle of radius \( r = 0.85 \) m using a massless rope as shown in the figure. The tangential speed of the water bucket varies around the circle, but is such that at the top of the circle the tangential speed is just high enough to keep the bucket moving in a circular path.

18) The minimum tangential speed, \( v_t \) of the bucket at the top of the circle is:

a. \( v_t = 4.08 \) m/s
b. \( v_t = 3.13 \) m/s
c. \( v_t = 5.78 \) m/s
d. \( v_t = 8.34 \) m/s
e. \( v_t = 2.89 \) m/s

\[
\begin{align*}
\text{Negative } mg \\
\sqrt{\left(\frac{mg}{r}\right)^2 + \left(\omega \delta\right)^2}
\end{align*}
\]
A metal bucket with mass 1.5 kg containing water of mass 3 kg is swung in a vertical circle of radius \( r = 0.85 \) m using a massless rope as shown in the figure. The tangential speed of the water bucket varies around the circle, but is such that at the top of the circle the tangential speed is just high enough to keep the bucket moving in a circular path.

18) The minimum tangential speed, \( v_t \) of the bucket at the top of the circle is:

a. \( v_t = 4.08 \) m/s  
b. \( v_t = 3.13 \) m/s  
c. \( v_t = 5.78 \) m/s  
d. \( v_t = 8.34 \) m/s  
--- Circled Answer ---  
e. \( v_t = 2.89 \) m/s
A metal bucket with mass 1.5 kg containing water of mass 3 kg is swung in a vertical circle of radius $r = 0.85$ m using a massless rope as shown in the figure. The tangential speed of the water bucket varies around the circle, but is such that at the top of the circle the tangential speed is just high enough to keep the bucket moving in a circular path.

19) What is the tension in the rope when the bucket is at its lowest point assuming its tangential velocity is 6.97 m/s.

a. $T = 257$ N  

b. $T = 44.1$ N  

c. $T = 301$ N  

d. $T = 100$ N  

e. $T = 213$ N
A metal bucket with mass 1.5 kg containing water of mass 3 kg is swung in a vertical circle of radius $r = 0.85$ m using a massless rope as shown in the figure. The tangential speed of the water bucket varies around the circle, but is such that at the top of the circle the tangential speed is just high enough to keep the bucket moving in a circular path.

19) What is the tension in the rope when the bucket is at its lowest point assuming its tangential velocity is 6.97 m/s.

a. $T = 257$ N  

b. $T = 441$ N  

c. $T = 301$ N  

d. $T = 100$ N  

e. $T = 213$ N
A car of mass \( m = 2400 \text{ kg} \) is driving with constant speed \( v = 35 \text{ m/s} \) on a circular track of radius \( R = 26 \text{ m} \).

20) What is the magnitude of the acceleration (note \( g = 9.8 \text{ m/s}^2 \))? 

a. \( a = 6.7g \)
b. \( a = 5.8g \)
c. \( a = 4.8g \)
A car of mass \( m = 2400 \text{ kg} \) is driving with constant speed \( v = 35 \text{ m/s} \) on a circular track of radius \( R = 26 \text{ m} \).

20) What is the magnitude of the acceleration (note \( g = 9.8 \text{ m/s}^2 \))? 

- a. \( a = 6.7g \)
- b. \( a = 5.8g \)
- c. \( a = 4.8g \)
A car of mass $m = 2400$ kg is driving with constant speed $v = 35$ m/s on a circular track of radius $R = 26$ m.

21) At the moment the car is pointing North, a passenger drops a rock out the window of the car. As viewed from above, what direction will the rock travel?

a. North
b. West
c. East
A car of mass $m = 2400$ kg is driving with constant speed $v = 35$ m/s on a circular track of radius $R = 26$ m.

21) At the moment the car is pointing North, a passenger drops a rock out the window of the car. As viewed from above, what direction will the rock travel?

a. North  

b. West  

c. East
In a triathlon, a contestant swims in a straight line from start to finish in a time \( T \). In order to do so, the contestant has to swim against the flow of the river which has a constant speed \( V \) relative to ground.

22) What is the \( x \)-component of the swimmer’s velocity, \( v_x \), with respect to the water? (Note the variables used in these equations \( D, T, V, \) and \( W \) are all positive.)

\[
\begin{align*}
\text{a. } v_x &= \frac{D}{T} + V \\
\text{b. } v_x &= \frac{D}{T} - V \\
\text{c. } v_x &= \frac{W}{T} + V \\
\text{d. } v_x &= \frac{W}{T} - V \\
\text{e. } v_x &= \frac{D}{T}
\end{align*}
\]
In a triathlon, a contestant swims in a straight line from start to finish in a time $T$. In order to do so, the contestant has to swim against the flow of the river which has a constant speed $V$ relative to ground.

22) What is the $x$-component of the swimmer’s velocity, $v_x$, with respect to the water? (Note the variables used in these equations $D, T, V,$ and $W$ are all positive.)

\[ a. \ v_x = \frac{D}{T} + V \]
\[ b. \ v_x = \frac{D}{T} - V \]
\[ c. \ v_x = \frac{W}{T} + V \]
\[ d. \ v_x = \frac{W}{T} - V \]
\[ e. \ v_x = \frac{D}{T} \]
The moon has mass $M_M = 7.3 \times 10^{22}$ kg. It revolves around the Earth in a circular orbit of radius $R_{\text{MOON}} = 3.84 \times 10^8$ m with period $T = 27.3$ days. The Earth has mass $M_e = 6 \times 10^{24}$ kg. The gravitational constant is $G = 6.67 \times 10^{-11}$ Nm$^2$/kg$^2$.

23) What is the magnitude of the force of the earth on the moon? 

\[ |F| = \frac{G M_m m}{r^2} \]

a. $|F_{\text{earth-moon}}| = 1.98 \times 10^{20}$ N

b. $|F_{\text{earth-moon}}| = 7.15 \times 10^{23}$ N

c. $|F_{\text{earth-moon}}| = 5.88 \times 10^{25}$ N
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24) The speed of the moon relative to the center of the earth is $V_{\text{moon}}$. Suppose a satellite is in a circular orbit of 
radius $R_{\text{SAT}}$ around the Earth and is moving with a speed relative to the center of the earth which is **less** 
than $V_{\text{moon}}$. Compare $R_{\text{SAT}}$ to $R_{\text{MOON}}$

- a. $R_{\text{SAT}} > R_{\text{MOON}}$
- b. $R_{\text{SAT}} < R_{\text{MOON}}$
- c. More information about the satellite is needed to answer this question.

\[
\frac{4\pi^2}{T^2} = \frac{GM}{r^3}
\]

\[
\omega^2 = \frac{GM}{r^2}
\]
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