Nagy,

Tibor

Keep this exam CLOSED until advised by the instructor.

50 minute long closed book exam.

Fill out the bubble sheet: last name, first initial, student number. Leave the section, code and form areas empty.

A two-sided handwritten 8.5 by 11 help sheet is allowed.

When done, hand in your test and your bubble sheet.

Thank you and good luck!

Possibly useful constant:

- $g = 9.81 \text{ m/s}^2$
Please, sit in row C.

1 pt  Are you sitting in the seat assigned?

1. A ☐ Yes, I am.
An apple, a brick and a hammer are all dropped from the second floor of a building. Which object(s) will hit the ground first?

2. A  The hammer and the apple will hit the ground first in a tie.
   B  They all hit the ground at the same time.
   C  Without knowing the masses of the objects, we cannot tell which one hits the ground first.
   D  The apple will hit first.
   E  The hammer will hit first.
   F  The apple and the brick will hit the ground first in a tie.
   G  The brick and the hammer will hit the ground first in a tie.
   H  The brick will hit first.
A car is initially at rest on a straight road. The histogram shows the car’s acceleration along that road as a function of time.

\[ a = \frac{\Delta v}{\Delta t} \]

\[ \Rightarrow \Delta v = a \cdot \Delta t \]

3 pt Calculate the speed of the car at \( t = 4 \) s.

\( \text{(in m/s)} \)

3. \( \text{A} \) 2 \( \text{B} \) 3 \( \text{C} \) 4 \( \text{D} \) 5 \( \text{E} \) 6 \( \text{F} \) 7 \( \text{G} \) 8 \( \text{H} \) 9

\[ v = v_0 + a \cdot \Delta t \]

\[ \Delta t = 1 \text{ s} \]

\[ v = 0 + 0 + 2 + 1 - 1 = 2 \text{ m/s} \]
A large rock is released from rest from the top of a tall building. The average speed of the rock during the first second of the fall is 5 m/s. What is the average speed of the rock during the third second?

Galileo’s pattern:

5, 15, 25, 35, 45…
in the relative ratios of the consecutive odd numbers:

1, 3, 5, 7, 9,…
4 pt A boat crossing a 277.0 m wide river is directed so that it will cross the river and land on the opposite shore directly across from the starting point.

The boat has a speed of 5.20 m/s in still water and the river flows uniformly at 3.70 m/s. Calculate the time required for the boat to reach the opposite shore.

\( \text{in s} \)

5. \( \boxed{A \ 1.59 \times 10^1} \) \( \boxed{B \ 1.99 \times 10^1} \) \( \boxed{C \ 2.48 \times 10^1} \) \( \boxed{D \ 3.11 \times 10^1} \) 
\( \boxed{E \ 3.88 \times 10^1} \) \( \boxed{F \ 4.85 \times 10^1} \) \( \boxed{G \ 6.06 \times 10^1} \) \( \boxed{H \ 7.58 \times 10^1} \)
A baseball is projected horizontally with an initial speed of 20.5 m/s from a height of 1.51 m. At what horizontal distance will the ball hit the ground? (Neglect air friction.)

\[
\text{in m}
\]

6. \(A\) \(1.14 \times 10^1\)  \(B\) \(1.33 \times 10^1\)  \(C\) \(1.56 \times 10^1\)  \(D\) \(1.82 \times 10^1\)  
\(E\) \(2.13 \times 10^1\)  \(F\) \(2.49 \times 10^1\)  \(G\) \(2.92 \times 10^1\)  \(H\) \(3.41 \times 10^1\)

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

Distance travelled horizontally:
\[
d = v \cdot t = v \sqrt{\frac{2h}{g}}
\]
4 pt A boy standing on top of a building throws a small ball from a height of $H_1 = 21.0$ m. (See figure.)

The ball leaves with a speed of $26.8$ m/s, at an angle of $75.0^\circ$ to the horizontal, and lands on a building with a height $H_2 = 36.6$ m. Neglect air friction, and calculate for how long the ball is in the air.

\[ \text{(in s)} \]

7. \( \text{A} \) 1.50 \( \text{B} \) 1.88 \( \text{C} \) 2.35 \( \text{D} \) 2.93 \( \text{E} \) 3.67 \( \text{F} \) 4.58 \( \text{G} \) 5.73 \( \text{H} \) 7.16

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\[ \begin{align*}
\vec{v}_0 \\
\theta
\end{align*} \]

\[ v_{0y} = v_0 \cdot \sin \theta \]

\[ y(t) = H_1 + v_{0y} \cdot t - \frac{1}{2} g \cdot t^2 \]

at \( t = t^\ast \):

\[ \begin{align*}
H_1 + v_0 \cdot (\sin \theta) \cdot t^\ast - \frac{1}{2} g \cdot t^2 &= H_2 \\
0 &= \frac{1}{2} g \cdot t^{\ast 2} - v_0 \cdot (\sin \theta) \cdot t^\ast + (H_2 - H_1)
\end{align*} \]

\[ t_{1,2}^\ast = \frac{v_0 \cdot \sin \theta \pm \sqrt{(v_0 \cdot \sin \theta)^2 - 4 \cdot \frac{1}{2} g \cdot (H_2 - H_1)}}{2 \cdot \frac{1}{2} g} \]

\[ t_{1,2}^\ast = \frac{v_0 \cdot \sin \theta \pm \sqrt{(v_0 \cdot \sin \theta)^2 - 2g(H_2 - H_1)}}{g} \]

You will get two positive roots. You will need the larger one.
At the fundamental, microscopic level which of the following forces are electromagnetic in nature?

- tension force
- buoyant force
- all the forces on this list
- static friction
- kinetic friction
- air drag
- none of the forces on this list
- normal force

All contact forces in everyday life are the results of electromagnetic interactions between electrons. 

nucleus: positive protons and neutral neutrons are here.
An \( m = 7.25 \text{ kg} \) mass is suspended on a string which is pulled upward by a force of \( F = 76.5 \text{ N} \) as shown in the figure.

If the upward velocity of the mass is 2.25 m/s right now, then what is the velocity 5.50 s later? (in m/s)

9. A \( \approx 6.35 \)  
   B \( \approx 7.17 \)  
   C \( \approx 8.10 \)  
   D \( \approx 9.16 \)  
   E \( \approx 1.03 \times 10^1 \)  
   F \( \approx 1.17 \times 10^1 \)  
   G \( \approx 1.32 \times 10^1 \)  
   H \( \approx 1.49 \times 10^1 \) 

\[
\begin{align*}
F_{\text{net}} &= ma \\
F - mg &= ma \\
\frac{F - mg}{m} &= a \\
v &= v_0 + at
\end{align*}
\]
Two forces $F_1 = -8.30 \mathbf{i} + 5.50 \mathbf{j}$ and $F_2 = 6.30 \mathbf{i} + 7.60 \mathbf{j}$ are acting on a mass of $m = 6.50$ kg. The forces are measured in newtons. What is the magnitude of the object’s acceleration? (in $\text{m/s}^2$)

10. A $\approx 6.52 \times 10^{-1}$  
    B $\approx 8.67 \times 10^{-1}$  
    C $\approx 1.15$  
    D $\approx 1.53$  
    E $\approx 2.04$  
    F $\approx 2.71$  
    G $\approx 3.61$  
    H $\approx 4.80$

\[
\begin{align*}
\vec{F}_1 &= -8.3 \mathbf{i} + 5.5 \mathbf{j} \\
\vec{F}_2 &= 6.3 \mathbf{i} + 7.6 \mathbf{j} \\
\vec{F}_{\text{net}} &= -2.0 \mathbf{i} + 13.1 \mathbf{j} \\
F_{\text{net}} &= |\vec{F}_{\text{net}}| = \sqrt{(-2.0)^2 + 13.1^2} \\
\alpha &= \frac{F_{\text{net}}}{m}
\end{align*}
\]
The radius of curvature of a highway exit is $r = 82.5 \text{ m}$. The surface of the exit road is horizontal, not banked. (See figure.)

![Diagram of highway exit](image)

11. What is the minimum required value of the coefficient of static friction between the surface of the road and the tires so that the car can exit the highway safely without sliding at a constant speed of $53.8 \text{ km/h}$?

   - A $1.47 \times 10^{-1}$
   - B $1.72 \times 10^{-1}$
   - C $2.02 \times 10^{-1}$
   - D $2.36 \times 10^{-1}$
   - E $2.76 \times 10^{-1}$
   - F $3.23 \times 10^{-1}$
   - G $3.78 \times 10^{-1}$
   - H $4.42 \times 10^{-1}$

The static friction $f_s$ keeps the car on a circular path:

$$f_s = ma_{cp}$$

$$\mu_s N = m \frac{v^2}{r}$$

$$\mu_s mg = m \frac{v^2}{r}$$

$$\mu_s = \frac{v^2}{gr}$$

$(3.6 \text{ km/h} = 1 \text{ m/s})$
10 pt M₁ and M₂ have equal masses and are connected as shown. T₁ and T₂ are the tensions in the rope. The pulley is frictionless and massless. The incline is frictionless and is at an angle of \( \theta = 30.0^\circ \) from the horizontal. The quantities T₁, T₂ and g are magnitudes.

- The magnitude of the acceleration of M₁ is ___ that of M₂
  12. A greater than  B less than  C equal to

- T₂ is ___ M₂ g \sin(\theta)
  13. A greater than  B less than  C equal to

- T₁ is ___ M₂g
  14. A greater than  B less than  C equal to

- T₁ is ___ T₂
  15. A greater than  B less than  C equal to

- T₁ is ___ M₁g
  16. A greater than  B less than  C equal to

The system accelerates with M₁ down and M₂ uphill, because M₁ = M₂ and M₂ is on a frictionless incline.

\[ a₁ = a₂ \quad (\text{and} \quad v₁ = v₂ \quad \text{and} \quad \Delta x₁ = \Delta x₂) \]

because the rope doesn't stretch.

\[ M₁g > T₁ = T₂ > M₂g \cdot \sin \theta \]

because the pulley is ideal
Two masses $M_1 = 2.00 \text{ kg}$ and $M_2 = 8.70 \text{ kg}$ are stacked on top of each other as shown in the figure. The static coefficient of friction between $M_1$ and $M_2$ is $\mu_s = 0.220$. There is no friction between $M_2$ and the surface below it.

What is the maximum horizontal force that can be applied to $M_2$ without $M_1$ sliding relative to $M_2$? (in N)

17. A $\times 5.55$  B $\times 7.38$  C $\times 9.82$  D $\times 1.31 \times 10^3$
E $\times 1.74 \times 10^1$  F $\times 2.31 \times 10^1$  G $\times 3.07 \times 10^1$  H $\times 4.08 \times 10^1$

\[
M_1: \quad f_s = M_1 \cdot a \\
\mu_s M_1 g = M_1 a \\
\mu_s g = a \\
(M_1 + M_2): \quad F = (M_1 + M_2) a \\
F = (M_1 + M_2) \mu_s g
\]