CONCEPT DEVELOPMENT of 1D KINEMATICS

1) i) -
   ii) +
   iii) 0
   iv) -
   v) 2

2) i) 2 & 3
   ii) 1 & 3
   iii) 4

3) situation  rank
   i) all same
   ii) all same
   iii) all same
   iv) all same

CONCEPT DEVELOPMENT of 2D KINEMATICS

1) c

2) d

3) b

4) a or b
Actual AP B PROBLEMS for the STUDY of KINEMATICS

1) AP B 2000 Exam Problem #1

a. Indicate every time t for which the cart is at rest.  t = 4 s, t = 18 s

b. Indicate every time interval for which the speed (magnitude of velocity) of the cart is increasing.
   t = 4 s to 9 s, t = 18 s to 20 s

c. Determine the horizontal position x of the cart at t = 9.0 s if the cart is located at x = 2.0 m at t = 0.
   x = 1.1 m

d. On the axes below, sketch the acceleration a versus time t graph for the motion of the cart from t = 0 to t = 25 s.

   ![Graph of acceleration vs. time](image)

   e) i. The time from when the cart leaves the track until it first hits the floor
       t = 0.28 s

   ii. The horizontal distance from the end of the track to the point at which the cart first hits the floor
       x = 0.22 m

   iii. The kinetic energy of the cart immediately before it hits the floor
       $K_{e_f} = 2.2 \text{ J}$
Actual AP B PROBLEMS for the STUDY of KINEMATICS

2) AP B 1994 Exam Problem #1

a. Determine the magnitude of the average net force exerted on the ball during the kick.
   \[ F = 200 \text{ N} \]

b. Determine the time it takes for the ball to reach the plane of the fence.
   \[ t = 2 \text{ s} \]

c. Will the ball hit the fence? If so, how far below the top of the fence will it hit? If not, how far above the top of the fence will it pass?
   \[ y = 4 \text{ m} \text{ (so ball clears fence by 1.5 m)} \]

d. On the axes below, sketch the horizontal and vertical components of the velocity of the ball as functions of time until the ball reaches the plane of the fence.
CONCEPT DEVELOPMENT of NEWTON'S LAWS of MOTION

1) b
2) c
3) d
4) a
5) d
6) b

1988 AP B Exam Free Response Problem 1

A helicopter holding a 70-kilogram package suspended from a rope 5.0 meters long accelerates upward at a rate of 5.2 m/s². Neglect air resistance on the package.

a. On the diagram below, draw and label all of the forces acting on the package.

![Diagram of forces on the package](image)

b. Determine the tension in the rope.

\[ T = 1050 \text{ N} \]

c. When the upward velocity of the helicopter is 30 meters per second, the rope is cut and the helicopter continues to accelerate upward at 5.2 m/s². Determine the distance between the helicopter and the package 2.0 seconds after the rope is cut.

distance apart = 35 m
2000 AP B Exam Free Response Problem

a. On the figure below, draw and label all the forces on block \( m_1 \).

Express your answers to each of the following in terms of \( m_1, m_2, g, \theta, \) and \( f \).

b. Determine the coefficient of kinetic friction between the inclined plane and block 1.

\[
\mu_k = \frac{f}{(m_1 g \cos \theta)}
\]

c. Determine the value of the suspended mass \( M \) that allows blocks 1 and 2 to move with constant velocity down the plane.

\[
M = m_1 \sin \theta + m_2 \sin \theta + \frac{3f}{g}
\]

d. The string between blocks 1 and 2 is now cut. Determine the acceleration of block 1 while it is on the inclined plane.

\[
\text{SF: } m_1 g \sin \theta - m_1 g \cos \theta = m_1 a
\]

\[
a = g(\sin \theta - \mu \cos \theta) = \frac{g \sin \theta - f}{m_1}
\]
CONCEPT DEVELOPMENT for WORK, ENERGY, and POWER

1) c

2) b

3) c

Actual AP B Free Response PROBLEMS for the STUDY of WORK, ENERGY, and POWER

1988 AP Physics B Free Response Problem 1

a. What is the speed of the ball immediately after it rebounds from the surface?

\[ v = 10 \text{ m/s} \]

b. What fraction of the ball's initial kinetic energy is apparently lost during the bounce?

Fraction "lost" = 5/9

c. If the specific heat of the ball is 1,800 J/kg °C, and if all of the lost energy is absorbed by the molecules of the ball, by how much does the temperature of the ball increase?

\[ \Delta T = 0.0347 \text{° C} \]
a. Calculate the potential, kinetic, and total energies of the ball at time t = 0.
   \[ PE = 320 \text{ J}, \quad KE = 180 \text{ J}, \quad E = 500 \text{ J} \]

b. On the axes below, sketch and label graphs of the potential, kinetic, and total energies of the ball as functions of the distance fallen from the top of the cliff.

c. On the axes below sketch and label the kinetic and potential energies of the ball as functions of time until the ball hits.
CONCEPT DEVELOPMENT of LINEAR MOMENTUM

1) c
2) a
3) b
4) b

ACTUAL AP B FREE RESPONSE PROBLEMS for the STUDY of LINEAR MOMENTUM

2001 AP B Free Response Problem

a. Calculate the speed of the 0.50 kg target ball immediately after the collision.
   \[ v = 0.42 \text{ m/s} \]

b. Calculate the horizontal displacement \( d \).
   \[ d = 0.205 \text{ m} \]

c. Calculate the speed \( v \) of the target ball C immediately after the collision.
   \[ v = 0.306 \text{ m/s} \]

d. Calculate the y-component of incident ball A's momentum immediately after the collision.
   \[ p_{fAy} = 0.0153 \text{ kgm/s (up)} \]
1984 AP B Free Response Problem 2

a. Calculate the x and y components (p\textsubscript{x} and p\textsubscript{y}, respectively) of the momenta of the two objects before and after the collision, and write your results in the proper places in the following table.

<table>
<thead>
<tr>
<th></th>
<th>(M_1 = 1 \text{ kg})</th>
<th></th>
<th>(M_2 = 4 \text{ kg})</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before</strong></td>
<td>(p_x (\text{kg \cdot m/s}))</td>
<td>(p_y (\text{kg \cdot m/s}))</td>
<td>(p_x (\text{kg \cdot m/s}))</td>
</tr>
<tr>
<td><strong>Collision</strong></td>
<td>16</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>After</strong></td>
<td>0</td>
<td>-12</td>
<td>16</td>
</tr>
</tbody>
</table>

b. Show, using the data that you listed in the table, that linear momentum is conserved in this collision.

Total before = 16 kgm/s = total after = 16 kgm/s

c. Calculate the kinetic energy of the two-object system before and after the collision.

\[KE_i = 128 \text{ J}\]

\[KE_f = 122 \text{ J}\]

d. Is kinetic energy conserved in the collision?

No
CONCEPT DEVELOPMENT for CIRCULAR MOTION and ROTATION

1) b

2) b

3) i) yes
   ii) no
   iii) yes
   iv) yes

4) b

ACTUAL AP B FREE RESPONSE PROBLEMS for the STUDY of CIRCULAR MOTION and ROTATION

2001 AP B Free Response Problem 1

a. On the figures below, draw and label all the forces exerted on the ball when it is at points P and Q, respectively.

b. Derive an expression for \( v_{\text{min}} \), the minimum speed the ball can have at point Z without leaving the circular path.

\[ v_{\text{min}} = \sqrt{gr} \]

c. The maximum tension the string can have without breaking is \( T_{\text{max}} \). Derive an expression for \( v_{\text{max}} \), the maximum speed the ball can have at point Q without breaking the string.

\[ v_{\text{max}} = \sqrt{r \left( T_{\text{max}} - mg \right)/m} \]

d. Suppose that the string breaks at the instant the ball is at point P. Describe the motion of the ball immediately after the string breaks.

The ball would travel straight up, to a maximum height, and then straight down.
1997 AP B Free Response Problem 2

a. Explain how the students, by using a timer and the information given above, can determine the speed of the ball as it is revolving.
   
   Use the radius to calculate the circumference \( c = 2\pi r \)
   
   Time a certain number of revolutions.
   
   Speed = total distance / total time = (# rev)(2\pi r) / (total time)

b. How much work is done by the cord in one revolution? Explain how you arrived at your answer.
   
   \( W = 0 \).

c. The speed of the ball is determined to be 3.7 m/s. Assuming that the cord is horizontal as it swings, calculate the expected tension in the cord.
   
   \( T = 5.5 \text{ N} \)

d. The actual tension in the cord as measured by the spring scale is 5.8 N. What is the percent difference between this measured value of the tension and the value calculated in part c. ?
   
   5.2 %

e. The students find that, despite their best efforts, they cannot swing the ball so that the cord remains exactly horizontal.
   
   i. On the picture of the ball below, draw vectors to represent the forces acting on the ball and identify the force that each vector represents.

   ![Diagram of forces](image)

   ii. Explain why it is not possible for the ball to swing so that the cord remains exactly horizontal.

   There needs to be a (upward) vertical component in the tension to balance the downward vertical gravitational force.

   iii. Calculate the angle that the cord makes with the horizontal.

   \( \theta = 19.8^\circ \)
CONCEPT DEVELOPMENT for OSCILLATIONS and GRAVITATION

GRAVITATION
1. c
2. b
3. c

OSCILLATIONS
1. b & c
2. b
AP B 1995 Exam Problem #1

a) Determine the following for the 0.20 kilogram mass immediately before the impact.

   i. Its linear momentum
      \[ p = 0.60 \text{ kgm/s} \]

   ii. Its kinetic energy
      \[ KE = 0.9 \text{ J} \]

b) Determine the following for the combined masses immediately after the impact.

   i. The linear momentum
      \[ p = 0.60 \text{ kgm/s} \]

   ii. The kinetic energy
      \[ KE = 0.12 \text{ J} \]

After the collision, the two masses undergo simple harmonic motion about their position at impact.

(c) Determine the amplitude of the harmonic motion.

   \[ x = 0.05 \text{ m} \]

(d) Determine the period of the harmonic motion.

   \[ T = 0.77 \text{ s} \]
AP B 1975 Exam Problem #7

a. In the space below draw a force diagram identifying all of the forces acting on the object while it is held by the string.

![Force Diagram](attachment:force_diagram.png)

b. Determine the tension in the cord before the string is burned.

\[ T = 2mg \]

![Tension Diagram](attachment:tension_diagram.png)

t, 2mg

c. Show that the cord, strong enough to support the object before the string is burned, is also strong enough to support the object as it passes through the bottom of its swing.

\[ T = 2mg, \text{ same as at rest, so string is strong enough} \]

d. The motion of the pendulum after the string is burned is periodic. Is it also simple harmonic? Why, or why not?

Not simple harmonic, true SHM is linear, restoring force always pulls back toward equilibrium.