

KnapSack

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Introduction

KnapSack is a C library providing structures and functions to solve the 0/1 knapsack problem: given a set of item with a cost and value, which subset of items has the maximum total value while the total cost stays under a given budget.

It uses the `PBErr` and `GSet` library.

1 Definitions

The definition of the knapsack problem and its solution can be found on Wikipedia:

https://en.wikipedia.org/wiki/Knapsack_problem

2 Interface

```
// ===== KNAPSACK.H =====

#ifndef KNAPSACK_H
#define KNAPSACK_H

// ===== Include =====

#include <stdlib.h>
#include <stdio.h>
#include <math.h>
#include <string.h>
#include <stdbool.h>
#include "pberr.h"
#include "gset.h"

// ---- KnapSackPod

// ===== Data structure =====

typedef struct KnapSackPod {
    // ID
    int _id;
    // Cost
    int _cost;
    // Value
    int _val;
} KnapSackPod;

// ===== Functions declaration =====

// Create a new KnapSackPod with id 'id', cost 'cost' and value 'val'
KnapSackPod* KnapSackPodCreate(int id, int cost, int val);

// Free the memory used by the KnapSackPod 'that'
void KnapSackPodFree(KnapSackPod** that);

// Get the id of the KnapSackPod 'that'
#if BUILDMODE != 0
inline
#endif
int KSPGetId(KnapSackPod* that);

// Get the cost of the KnapSackPod 'that'
#if BUILDMODE != 0
inline
#endif
int KSPGetCost(KnapSackPod* that);

// Get the value of the KnapSackPod 'that'
#if BUILDMODE != 0
inline
#endif
int KSPGetValue(KnapSackPod* that);

// Set the cost of the KnapSackPod 'that' to 'cost'
```

```

#if BUILDMODE != 0
inline
#endif
void KSPSetCost(KnapSackPod* that, int cost);

// Set the value of the KnapSackPod 'that' to 'val'
#if BUILDMODE != 0
inline
#endif
void KSPSetValue(KnapSackPod* that, int val);

// ---- 0-1 KnapSack

// ===== Data structure =====

typedef struct KnapSack {
    // Budget
    int _budget;
    // GSet of selectable KnapSackPod
    GSetKnapSackPod _pods;
    // GSet of selected KnapSackPod
    GSetKnapSackPod _sel;
} KnapSack;

// ===== Functions declaration =====

// Create a new KnapSack with the budget 'budget'
KnapSack* KnapSackCreate(int budget);

// Free the memory used by the KnapSack 'that'
// The two GSetKnapSackPod are flushed but it's the responsibility
// of the user to free each KnapSackPod
void KnapSackFree(KnapSack** that);

// Get the budget of the KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
int KSGetBudget(KnapSack* that);

// Set the budget of the KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
void KSSetBudget(KnapSack* that, int budget);

// Get the GSet of selectable KnapSackPod of the KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
GSetKnapSackPod* KSPods(KnapSack* that);

// Select the best pods of the KnapSack 'that'
// https://en.wikipedia.org/wiki/Knapsack\_problem
void KSSelect(KnapSack* that);

// Get the GSet of selected KnapSackPod of the KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
GSetKnapSackPod* KSSelectedPods(KnapSack* that);

```

```

// Get the 'iPod'-th KnapSackPod of selectable pods of the
// KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
KnapSackPod* KSGetPod(KnapSack* that, int iPod);

// Get the number of selectable pods of the KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
int KSGetNbPod(KnapSack* that);

// Get the 'iPod'-th KnapSackPod of selected pods of the
// KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
KnapSackPod* KSGetSelectedPod(KnapSack* that, int iPod);

// Get the number of selected pods of the KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
int KSGetNbSelectedPod(KnapSack* that);

// Get the cost of the KnapSack 'that' for currently selected pods
int KSCost(KnapSack* that);

// Get the value of the KnapSack 'that' for currently selected pods
int KSGetValue(KnapSack* that);

// ===== Inliner =====

#if BUILDMODE != 0
#include "knapsack-inline.c"
#endif

#endif

```

3 Code

3.1 knapsack.c

```

// ===== KNAPSACK.C =====

// ===== Include =====

#include "knapsack.h"
#if BUILDMODE == 0
#include "knapsack-inline.c"
#endif

// ---- KnapSackPod

// ===== Functions implementation =====

```

```

// Create a new KnapSackPod with id 'id', cost 'cost' and value 'val'
KnapSackPod* KnapSackPodCreate(int id, int cost, int val) {
#if BUILDMODE == 0
    if (cost <= 0) {
        GSetErr->_type = PBErrTypeInvalidArg;
        sprintf(GSetErr->_msg, "'cost' is invalid (0<=%d)", cost);
        PBErrCatch(GSetErr);
    }
    if (val <= 0) {
        GSetErr->_type = PBErrTypeInvalidArg;
        sprintf(GSetErr->_msg, "'val' is invalid (0<=%d)", val);
        PBErrCatch(GSetErr);
    }
#endif
    // Declare the new pod
    KnapSackPod* pod = PBErrMalloc(KnapSackErr, sizeof(KnapSackPod));
    // Set properties
    pod->_id = id;
    pod->_cost = cost;
    pod->_val = val;
    // Return the new pod
    return pod;
}

// Free the memory used by the KnapSackPod 'that'
void KnapSackPodFree(KnapSackPod** that) {
    // Check argument
    if (that == NULL || *that == NULL)
        // Nothing to do
        return;
    // Free memory
    free(*that);
    *that = NULL;
}

// ---- KnapSack

// ===== Define =====

#define KSMAX(a,b) ((a)>(b)?(a):(b))

// ===== Functions implementation =====

// Create a new KnapSack with the budget 'budget'
KnapSack* KnapSackCreate(int budget) {
#if BUILDMODE == 0
    if (budget < 0) {
        GSetErr->_type = PBErrTypeInvalidArg;
        sprintf(GSetErr->_msg, "'budget' is invalid (0<=%d)", budget);
        PBErrCatch(GSetErr);
    }
#endif
    // Declare the new KnapSack
    KnapSack* that = PBErrMalloc(KnapSackErr, sizeof(KnapSack));
    // Set properties
    that->_pods = GSetKnapSackPodCreateStatic();
    that->_sel = GSetKnapSackPodCreateStatic();
    that->_budget = budget;
    // Return the new KnapSack
    return that;
}

```

```

// Free the memory used by the KnapSack 'that'
// The two GSetKnapSackPod are flushed but it's the responsibility
// of the user to free each KnapSackPod
void KnapSackFree(KnapSack** that) {
    // Check argument
    if (that == NULL || *that == NULL)
        // Nothing to do
        return;
    // Free memory
    GSetFlush(&((*that)->_pods));
    GSetFlush(&((*that)->_sel));
    free(*that);
    *that = NULL;
}

// Select the best pods of the KnapSack 'that'
// https://en.wikipedia.org/wiki/Knapsack_problem
void KSSelect(KnapSack* that) {
#ifdef BUILDMODE == 0
    if (that == NULL) {
        GSetErr->_type = PErrTypeNullPointer;
        sprintf(GSetErr->_msg, "'that' is null");
        PErrCatch(GSetErr);
    }
#endif
    // Flush the selected set
    GSetFlush(KSSelectedPods(that));
    // If there is no budget or no selectable pods
    if (KSGetNbPod(that) <= 0 || KSGetBudget(that) <= 0)
        // Nothing to do
        return;
    // Declare an array to calculate the solution
    int b = KSGetBudget(that) + 1;
    int* m = PErrMalloc(KnapSackErr,
        sizeof(int) * (KSGetNbPod(that) + 1) * b);
    // Initialise the array
    for (int cost = b; cost--;)
        m[cost] = 0;
    // Calculate values in the array
    for (int iPod = 1; iPod <= KSGetNbPod(that); ++iPod) {
        KnapSackPod* pod = KSGetPod(that, iPod - 1);
        for (int cost = 0; cost <= KSGetBudget(that); ++cost) {
            if (KSPGetCost(pod) > cost) {
                m[iPod * b + cost] = m[(iPod - 1) * b + cost];
            } else {
                m[iPod * b + cost] =
                    KSMAX(m[(iPod - 1) * b + cost],
                        m[(iPod - 1) * b + cost - KSPGetCost(pod)] +
                        KSPGetValue(pod));
            }
        }
    }
    // Find the selected pods
    int iPod = KSGetNbPod(that);
    int cost = KSGetBudget(that);
    while (iPod > 0 && cost > 0) {
        if (m[iPod * b + cost] != m[(iPod - 1) * b + cost]) {
            KnapSackPod* pod = KSGetPod(that, iPod - 1);
            GSetPush(KSSelectedPods(that), pod);
            cost -= KSPGetCost(pod);
        }
        --iPod;
    }
}

```

```

    }
    // Free memory
    free(m);
}

// Get the cost of the KnapSack 'that' for currently selected pods
int KSGetCost(KnapSack* that) {
    #if BUILDMODE == 0
        if (that == NULL) {
            GSetErr->_type = PBErrTypeNullPointer;
            sprintf(GSetErr->_msg, "'that' is null");
            PBErrCatch(GSetErr);
        }
    #endif
    // Declare a variable to calculate the cost
    int cost = 0;
    // Loop on selected pods and sum the cost
    if (KSGetNbSelectedPod(that) > 0) {
        GSetIterForward iter =
            GSetIterForwardCreateStatic(KSSelectedPods(that));
        do {
            KnapSackPod* pod = GSetIterGet(&iter);
            cost += KSPGetCost(pod);
        } while (GSetIterStep(&iter));
    }
    // Return the value
    return cost;
}

// Get the value of the KnapSack 'that' for currently selected pods
int KSGetValue(KnapSack* that) {
    #if BUILDMODE == 0
        if (that == NULL) {
            GSetErr->_type = PBErrTypeNullPointer;
            sprintf(GSetErr->_msg, "'that' is null");
            PBErrCatch(GSetErr);
        }
    #endif
    // Declare a variable to calculate the value
    int val = 0;
    // Loop on selected pods and sum the value
    if (KSGetNbSelectedPod(that) > 0) {
        GSetIterForward iter =
            GSetIterForwardCreateStatic(KSSelectedPods(that));
        do {
            KnapSackPod* pod = GSetIterGet(&iter);
            val += KSPGetValue(pod);
        } while (GSetIterStep(&iter));
    }
    // Return the value
    return val;
}

```

3.2 knapsack-inline.c

```

// ===== KNAPSACK-INLINE.C =====

// ---- KnapSackPod

```

```

// ===== Functions implementation =====

// Get the id of the KnapSackPod 'that'
#if BUILDMODE != 0
inline
#endif
int KSPGetId(KnapSackPod* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        GSetErr->_type = PBErrTypeNullPointer;
        sprintf(GSetErr->_msg, "'that' is null");
        PBErrCatch(GSetErr);
    }
#endif
    return that->_id;
}

// Get the cost of the KnapSackPod 'that'
#if BUILDMODE != 0
inline
#endif
int KSPGetCost(KnapSackPod* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        GSetErr->_type = PBErrTypeNullPointer;
        sprintf(GSetErr->_msg, "'that' is null");
        PBErrCatch(GSetErr);
    }
#endif
    return that->_cost;
}

// Get the value of the KnapSackPod 'that'
#if BUILDMODE != 0
inline
#endif
int KSPGetValue(KnapSackPod* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        GSetErr->_type = PBErrTypeNullPointer;
        sprintf(GSetErr->_msg, "'that' is null");
        PBErrCatch(GSetErr);
    }
#endif
    return that->_val;
}

// Set the cost of the KnapSackPod 'that' to 'cost'
#if BUILDMODE != 0
inline
#endif
void KSPSetCost(KnapSackPod* that, int cost) {
#if BUILDMODE == 0
    if (that == NULL) {
        GSetErr->_type = PBErrTypeNullPointer;
        sprintf(GSetErr->_msg, "'that' is null");
        PBErrCatch(GSetErr);
    }
    if (cost <= 0) {
        GSetErr->_type = PBErrTypeInvalidArg;
        sprintf(GSetErr->_msg, "'cost' is invalid (0<%d)", cost);
        PBErrCatch(GSetErr);
    }
#endif
}

```



```

    }
#endif
    that->_cost = cost;
}

// Set the value of the KnapSackPod 'that' to 'val'
#if BUILDMODE != 0
inline
#endif
void KSPSetValue(KnapSackPod* that, int val) {
#if BUILDMODE == 0
    if (that == NULL) {
        GSetErr->_type = PErrTypeNullPointer;
        sprintf(GSetErr->_msg, "'that' is null");
        PErrCatch(GSetErr);
    }
    if (val <= 0) {
        GSetErr->_type = PErrTypeInvalidArg;
        sprintf(GSetErr->_msg, "'val' is invalid (0<=%d)", val);
        PErrCatch(GSetErr);
    }
#endif
    that->_val = val;
}

// ---- KnapSack

// ===== Functions implementation =====

// Get the budget of the KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
int KSGetBudget(KnapSack* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        GSetErr->_type = PErrTypeNullPointer;
        sprintf(GSetErr->_msg, "'that' is null");
        PErrCatch(GSetErr);
    }
#endif
    return that->_budget;
}

// Set the budget of the KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
void KSSetBudget(KnapSack* that, int budget) {
#if BUILDMODE == 0
    if (that == NULL) {
        GSetErr->_type = PErrTypeNullPointer;
        sprintf(GSetErr->_msg, "'that' is null");
        PErrCatch(GSetErr);
    }
    if (budget < 0) {
        GSetErr->_type = PErrTypeInvalidArg;
        sprintf(GSetErr->_msg, "'budget' is invalid (0<=%d)", budget);
        PErrCatch(GSetErr);
    }
#endif
    that->_budget = budget;
}

```

```

}

// Get the GSet of selectable KnapSackPod of the KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
GSetKnapSackPod* KSPods(KnapSack* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        GSetErr->_type = PBErrTypeNullPointer;
        sprintf(GSetErr->_msg, "'that' is null");
        PBErrCatch(GSetErr);
    }
#endif
    return &(that->_pods);
}

// Get the GSet of selected KnapSackPod of the KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
GSetKnapSackPod* KSSelectedPods(KnapSack* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        GSetErr->_type = PBErrTypeNullPointer;
        sprintf(GSetErr->_msg, "'that' is null");
        PBErrCatch(GSetErr);
    }
#endif
    return &(that->_sel);
}

// Get the 'iPod'-th KnapSackPod of selectable pods of the
// KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
KnapSackPod* KSGetPod(KnapSack* that, int iPod) {
#if BUILDMODE == 0
    if (that == NULL) {
        GSetErr->_type = PBErrTypeNullPointer;
        sprintf(GSetErr->_msg, "'that' is null");
        PBErrCatch(GSetErr);
    }
    if (iPod < 0) {
        GSetErr->_type = PBErrTypeInvalidArg;
        sprintf(GSetErr->_msg, "'iPod' is invalid (0<=%d)", iPod);
        PBErrCatch(GSetErr);
    }
#endif
    return GSetGet(KSPods(that), iPod);
}

// Get the number of selectable pods of the KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
int KSGetNbPod(KnapSack* that) {
#if BUILDMODE == 0
    if (that == NULL) {
        GSetErr->_type = PBErrTypeNullPointer;
        sprintf(GSetErr->_msg, "'that' is null");
    }
#endif
}

```

```

        PBErCatch(GSetErr);
    }
#endif
    return GSetNbElem(KSPods(that));
}

// Get the 'iPod'-th KnapSackPod of selected pods of the
// KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
KnapSackPod* KSGetSelectedPod(KnapSack* that, int iPod) {
    if BUILDMODE == 0
        if (that == NULL) {
            GSetErr->_type = PBErTypeNullPointer;
            sprintf(GSetErr->_msg, "'that' is null");
            PBErCatch(GSetErr);
        }
        if (iPod < 0) {
            GSetErr->_type = PBErTypeInvalidArg;
            sprintf(GSetErr->_msg, "'iPod' is invalid (0<=%d)", iPod);
            PBErCatch(GSetErr);
        }
    }
    return GSetGet(KSSelectedPods(that), iPod);
}

// Get the number of selected pods of the KnapSack 'that'
#if BUILDMODE != 0
inline
#endif
int KSGetNbSelectedPod(KnapSack* that) {
    if BUILDMODE == 0
        if (that == NULL) {
            GSetErr->_type = PBErTypeNullPointer;
            sprintf(GSetErr->_msg, "'that' is null");
            PBErCatch(GSetErr);
        }
    }
    return GSetNbElem(KSSelectedPods(that));
}

```

4 Makefile

```

#directory
PBERRDIR=../PBEr
GSETDIR=../GSet

# Build mode
# 0: development (max safety, no optimisation)
# 1: release (min safety, optimisation)
# 2: fast and furious (no safety, optimisation)
BUILDMODE=0

include $(PBERRDIR)/Makefile.inc

INCPATH=-I./ -I$(PBERRDIR)/ -I$(GSETDIR)/
BUILDOPTIONS=$(BUILDPARAM) $(INCPATH)

```

```

# compiler
COMPILER=gcc

#rules
all : main

main: main.o pberr.o knapsack.o gset.o Makefile
$(COMPILER) main.o pberr.o knapsack.o gset.o $(LINKOPTIONS) -o main

main.o : main.c $(PBERRDIR)/pberr.h knapsack.h knapsack-inline.c Makefile
$(COMPILER) $(BUILDOPTIONS) -c main.c

knapsack.o : knapsack.c knapsack.h knapsack-inline.c $(GSETDIR)/gset.h Makefile
$(COMPILER) $(BUILDOPTIONS) -c knapsack.c

pberr.o : $(PBERRDIR)/pberr.c $(PBERRDIR)/pberr.h Makefile
$(COMPILER) $(BUILDOPTIONS) -c $(PBERRDIR)/pberr.c

gset.o : $(GSETDIR)/gset.c $(GSETDIR)/gset-inline.c $(GSETDIR)/gset.h Makefile $(PBERRDIR)/pberr.h
$(COMPILER) $(BUILDOPTIONS) -c $(GSETDIR)/gset.c

clean :
rm -rf *.o main

valgrind :
valgrind -v --track-origins=yes --leak-check=full --gen-suppressions=yes --show-leak-kinds=all ./main

unitTest :
main > unitTest.txt; diff unitTest.txt unitTestRef.txt

```

5 Unit tests

```

#include <stdlib.h>
#include <stdio.h>
#include "pberr.h"
#include "knapsack.h"

void UnitTestKnapSackPodCreateFree() {
    KnapSackPod* pod = KnapSackPodCreate(1, 2, 3);
    if (pod == NULL ||
        pod->_id != 1 ||
        pod->_cost != 2 ||
        pod->_val != 3) {
        KnapSackErr->_type = PBErrTypeUnitTestFailed;
        sprintf(KnapSackErr->_msg, "KnapSackPodCreate failed");
        PBErrCatch(KnapSackErr);
    }
    KnapSackPodFree(&pod);
    if (pod != NULL) {
        KnapSackErr->_type = PBErrTypeUnitTestFailed;
        sprintf(KnapSackErr->_msg, "KnapSackPodFree failed");
        PBErrCatch(KnapSackErr);
    }
    printf("UnitTestKnapSackPodCreateFree OK\n");
}

void UnitTestKnapSackPodSetGet() {
    KnapSackPod* pod = KnapSackPodCreate(1, 2, 3);

```

```

    if (KSPGetCost(pod) != pod->_cost) {
        KnapSackErr->_type = PBErrTypeUnitTestFailed;
        sprintf(KnapSackErr->_msg, "KSGetCost failed");
        PBErrCatch(KnapSackErr);
    }
    KSPSetCost(pod, 4);
    if (KSPGetCost(pod) != 4) {
        KnapSackErr->_type = PBErrTypeUnitTestFailed;
        sprintf(KnapSackErr->_msg, "KSSetCost failed");
        PBErrCatch(KnapSackErr);
    }
    if (KSPGetValue(pod) != pod->_val) {
        KnapSackErr->_type = PBErrTypeUnitTestFailed;
        sprintf(KnapSackErr->_msg, "KSGetValue failed");
        PBErrCatch(KnapSackErr);
    }
    KSPSetValue(pod, 5);
    if (KSPGetValue(pod) != 5) {
        KnapSackErr->_type = PBErrTypeUnitTestFailed;
        sprintf(KnapSackErr->_msg, "KSSetValue failed");
        PBErrCatch(KnapSackErr);
    }
    if (KSPGetId(pod) != pod->_id) {
        KnapSackErr->_type = PBErrTypeUnitTestFailed;
        sprintf(KnapSackErr->_msg, "KSGetId failed");
        PBErrCatch(KnapSackErr);
    }
    KnapSackPodFree(&pod);
    printf("UnitTestKnapSackPodSetGet OK\n");
}

void UnitTestKnapSackPod() {
    UnitTestKnapSackPodCreateFree();
    UnitTestKnapSackPodSetGet();
    printf("UnitTestKnapSackPod OK\n");
}

void UnitTestKnapSackCreateFree() {
    KnapSack* ks = KnapSackCreate(1);
    if (ks == NULL ||
        ks->_budget != 1 ||
        GSetNbElem(&(ks->_pods)) != 0 ||
        GSetNbElem(&(ks->_sel)) != 0) {
        KnapSackErr->_type = PBErrTypeUnitTestFailed;
        sprintf(KnapSackErr->_msg, "KnapSackCreate failed");
        PBErrCatch(KnapSackErr);
    }
    KnapSackFree(&ks);
    if (ks != NULL) {
        KnapSackErr->_type = PBErrTypeUnitTestFailed;
        sprintf(KnapSackErr->_msg, "KnapSackFree failed");
        PBErrCatch(KnapSackErr);
    }
    printf("UnitTestKnapSackCreateFree OK\n");
}

void UnitTestKnapSackSetGet() {
    KnapSack* ks = KnapSackCreate(1);
    if (KSGetBudget(ks) != ks->_budget) {
        KnapSackErr->_type = PBErrTypeUnitTestFailed;
        sprintf(KnapSackErr->_msg, "KSGetBudget failed");
        PBErrCatch(KnapSackErr);
    }

```

```

}
KSSetBudget(ks, 2);
if (KSGetBudget(ks) != 2) {
    KnapSackErr->_type = PBErrTypeUnitTestFailed;
    sprintf(KnapSackErr->_msg, "KSSetBudget failed");
    PBErrCatch(KnapSackErr);
}
if (KSPods(ks) != &(ks->_pods)) {
    KnapSackErr->_type = PBErrTypeUnitTestFailed;
    sprintf(KnapSackErr->_msg, "KSPods failed");
    PBErrCatch(KnapSackErr);
}
if (KSSelectedPods(ks) != &(ks->_sel)) {
    KnapSackErr->_type = PBErrTypeUnitTestFailed;
    sprintf(KnapSackErr->_msg, "KSSelectedPods failed");
    PBErrCatch(KnapSackErr);
}
KnapSackPod* podA = KnapSackPodCreate(1, 2, 3);
KnapSackPod* podB = KnapSackPodCreate(4, 5, 6);
GSetAppend(KSPods(ks), podA);
GSetAppend(KSPods(ks), podB);
if (KSGetNbPod(ks) != 2) {
    KnapSackErr->_type = PBErrTypeUnitTestFailed;
    sprintf(KnapSackErr->_msg, "KSGetNbPod failed");
    PBErrCatch(KnapSackErr);
}
if (KSGetPod(ks, 0) != podA ||
    KSGetPod(ks, 1) != podB) {
    KnapSackErr->_type = PBErrTypeUnitTestFailed;
    sprintf(KnapSackErr->_msg, "KSGetPod failed");
    PBErrCatch(KnapSackErr);
}
GSetFlush(KSPods(ks));
GSetAppend(KSSelectedPods(ks), podA);
GSetAppend(KSSelectedPods(ks), podB);
if (KSGetNbSelectedPod(ks) != 2) {
    KnapSackErr->_type = PBErrTypeUnitTestFailed;
    sprintf(KnapSackErr->_msg, "KSGetNbSelectedPod failed");
    PBErrCatch(KnapSackErr);
}
if (KSGetSelectedPod(ks, 0) != podA ||
    KSGetSelectedPod(ks, 1) != podB) {
    KnapSackErr->_type = PBErrTypeUnitTestFailed;
    sprintf(KnapSackErr->_msg, "KSGetSelectedPod failed");
    PBErrCatch(KnapSackErr);
}
GSetFlush(KSSelectedPods(ks));
KnapSackPodFree(&podA);
KnapSackPodFree(&podB);
KnapSackFree(&ks);
printf("UnitTestKnapSackSetGet OK\n");
}

void UnitTestKnapSackSelect() {
    KnapSack* ks = KnapSackCreate(15);
    KnapSackPod* pods[5];
    int data[10] = {12, 4, 1, 2, 2, 2, 1, 1, 4, 10};
    for (int i = 5; i--;) {
        pods[i] = KnapSackPodCreate(i, data[2 * i], data[2 * i + 1]);
        GSetAppend(KSPods(ks), pods[i]);
    }
    KSSelect(ks);
}

```

```

if (KSGetNbSelectedPod(ks) != 4) {
    KnapSackErr->_type = PBErrTypeUnitTestFailed;
    sprintf(KnapSackErr->_msg, "KSSelect failed");
    PBErrCatch(KnapSackErr);
}
int check[4] = {4, 3, 2, 1};
for (int i = KSGetNbSelectedPod(ks); i--;)
    if (KSPGetId(KSGetSelectedPod(ks, i)) != check[i]) {
        KnapSackErr->_type = PBErrTypeUnitTestFailed;
        sprintf(KnapSackErr->_msg, "KSSelect failed");
        PBErrCatch(KnapSackErr);
    }
if (KSGetCost(ks) != 8) {
    KnapSackErr->_type = PBErrTypeUnitTestFailed;
    sprintf(KnapSackErr->_msg, "KSGetCost failed");
    PBErrCatch(KnapSackErr);
}
if (KSGetValue(ks) != 15) {
    KnapSackErr->_type = PBErrTypeUnitTestFailed;
    sprintf(KnapSackErr->_msg, "KSGetValue failed");
    PBErrCatch(KnapSackErr);
}
KnapSackFree(&ks);
for (int i = 5; i--;)
    KnapSackPodFree(pods + i);
printf("UnitTestKnapSackSelect OK\n");
}

void UnitTestKnapSack() {
    UnitTestKnapSackCreateFree();
    UnitTestKnapSackSetGet();
    UnitTestKnapSackSelect();
    printf("UnitTestKnapSack OK\n");
}

void UnitTestAll() {
    UnitTestKnapSackPod();
    UnitTestKnapSack();
    printf("UnitTestAll OK\n");
}

int main() {
    UnitTestAll();
    // Return success code
    return 0;
}

```

6 Unit tests output

```

UnitTestKnapSackPodCreateFree OK
UnitTestKnapSackPodSetGet OK
UnitTestKnapSackPod OK
UnitTestKnapSackCreateFree OK
UnitTestKnapSackSetGet OK
UnitTestKnapSackSelect OK
UnitTestKnapSack OK
UnitTestAll OK

```